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International Marine Engineering

DECEMBER, 1910.

LAUNCH OF THE OLYMPIC.

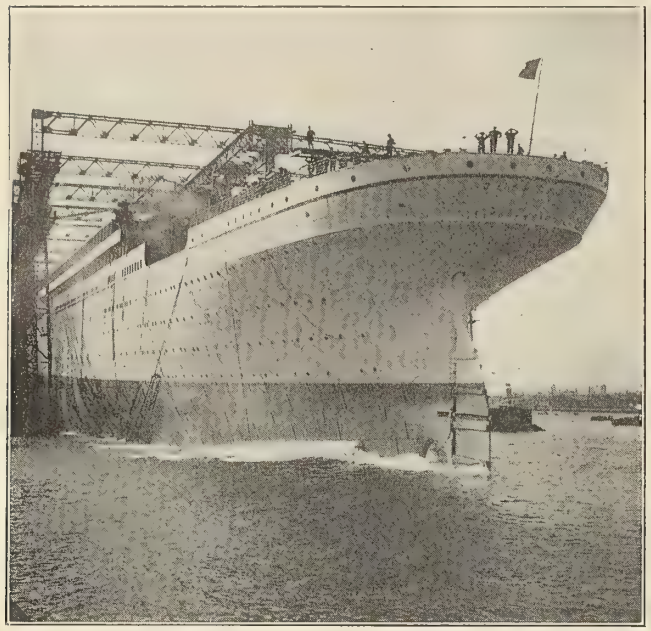
The most important launch of the year took place October 20th at the yards of Messrs. Harland & Wolf, Belfast, Ireland, when the giant 60,000-ton White Star liner *Olympic* left the ways. The *Olympic* is not only the largest ship in the world but she is as well the most notable example of the adoption of the combination system of turbines and reciprocating engines for propulsion.

The actual launch, from the time the vessel first began to move until she was completely waterborne, occupied sixty-two seconds. She moved steadily all the time, attaining at her highest speed on the ways a maximum rate of 12½ knots. When her stern was at its deepest immersion it was drawing 34 feet 6 inches of water, and when her bow left the ways it dipped to the extent of 18 feet 9 inches. Her mean draft as she lay in the river after launching was 18 feet ½ inch. The declivity of the ways was ⅜ of an inch per foot forward and ½ inch aft. For greasing the ways about 22 tons of tallow were used. The vessel was stopped within less than her own length without throwing any serious strain on the check chains or the anchors.

Like all the White Star boats, the *Olympic* is graceful, and only by comparison with other ships can her magnitude be appreciated. The launching weight, about 27,000 tons, was the heaviest weight ever tranferred from land to water, and this operation was naturally an undertaking of unusual importance, requiring the greatest forethought and most expert preparations. The method of launching was simple. The vessel was held on the ways by hydraulic triggers, only requiring to be released by the opening of a valve in order to allow the vast structure to glide into the water. The arrangements in launching did not end with the release of the vessel. They included provision for checking the way on the vessel when in the water. In the bed of the river were placed three heavy anchors on each side of the ship, each anchor being connected by a 7-inch steel wire hawser to eyeplates riveted to the shell plating. There were also placed in the bed of the river two piles of cable drags, each weighing over 80 tons, connected in a similar manner with an 8-inch steel-wire hawser. These were so arranged that when the vessel was clear of the end of the slip the drags and anchors acted simultaneously in bringing the ship to a standstill. The ship's own bow anchors were stowed in the hawse pipes, ready for letting go in case of emergency. So effectual were these methods that from the time the triggers were released, allowing the vessel to move, until the *Olympic* was stationary in the water, less than a couple of minutes elapsed. And as a feryman remarked to the writer, she made no more wave than his own old scow.

THE LARGEST STEAMSHIP IN THE WORLD, IMMEDIATELY AFTER LAUNCHING.

In the *Olympic* Harland & Wolff have repeated an achieve-

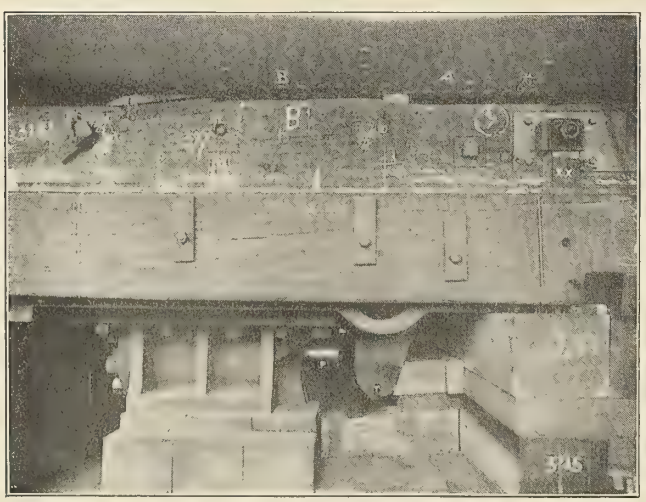


LAUNCH OF THE OLYMPIC.

ment already to their credit several times in the course of their history. Once more they have launched the largest vessel in the world. The White Star liner *Olympic* and her sister ship the *Titanic* are much larger than the *Lusitania* and the *Mauretania.* They are not intended to be fast ships, but they are notable as great specimens of naval architecture. The *Olympic* is of the following dimensions:

Length over all	882 ft. 6 in.
Breadth over all	92 ft. 6 in.
Breadth over boat deck	94 ft. 0 in.
Height from bottom of keel to boat deck	97 ft. 4 in.
Height from bottom of keel to top of captain's house	105 ft. 7 in.
Height of funnels above casing	72 ft. 0 in.
Height of funnels above boat deck	81 ft. 6 in.
Distance from top of funnel to keel	175 ft. 0 in.
Number of steel decks	11
Number of water-tight bulkheads	15
Gross tonnage	45,000 tons
Displacement at 34½ feet draft	60,000 tons

Apart from the *Lusitania* and the *Mauretania* one need not compare the *Olympic* and the *Titanic* with any vessels outside the White Star fleet. The development of the modern large intermediate steamer can be shown within that fleet. It dates from the *Oceanic* in 1899, and progress in size may be traced by taking a list of the White Star vessels and the Cunard express boats:

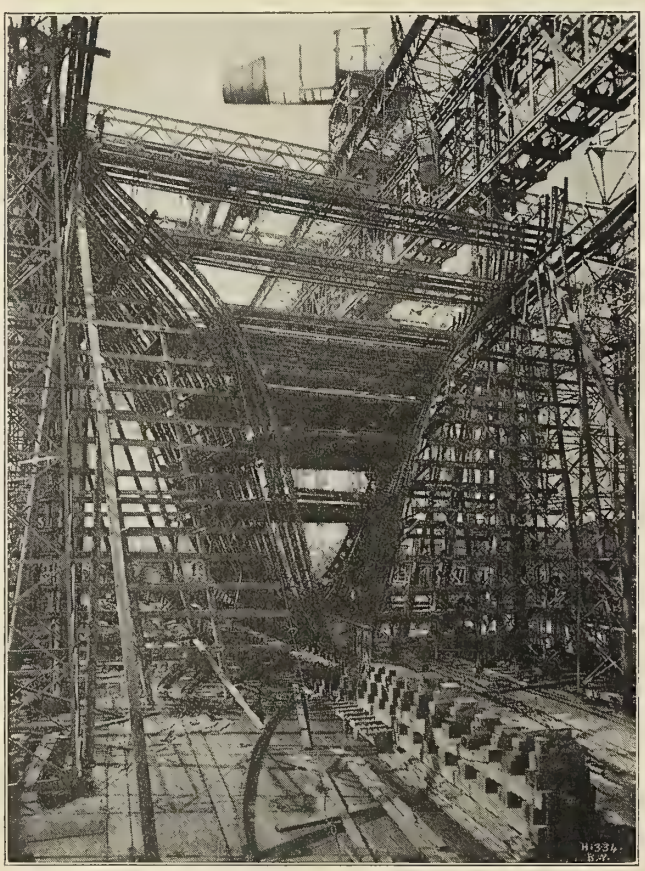


HYDRAULIC LAUNCHING TRIGGER.

Vessel and Type.	Tons.	Length.	Breadth.	Depth.	Speed.	Year.
Oceanic, T. s.s....	17,274	686	68	44	20	1899
Celtic, T. s.s.....	20,904	681	75	44	17	1901
Arabic, T. s.s.....	15,801	600	65	47	16	1903
Baltic, T. s.s.....	23,876	709	75	52	17	1904
Adriatic, T. s.s....	24,541	709	75	52	18	1906
Laurentic, 3 scr..	14,892	550	67	41	17	1908
Mauretania, 4 scr.	31,938	762	88	57	25	1907
Olympic, 3 scr....	45,000	*882	92	62	21	1910

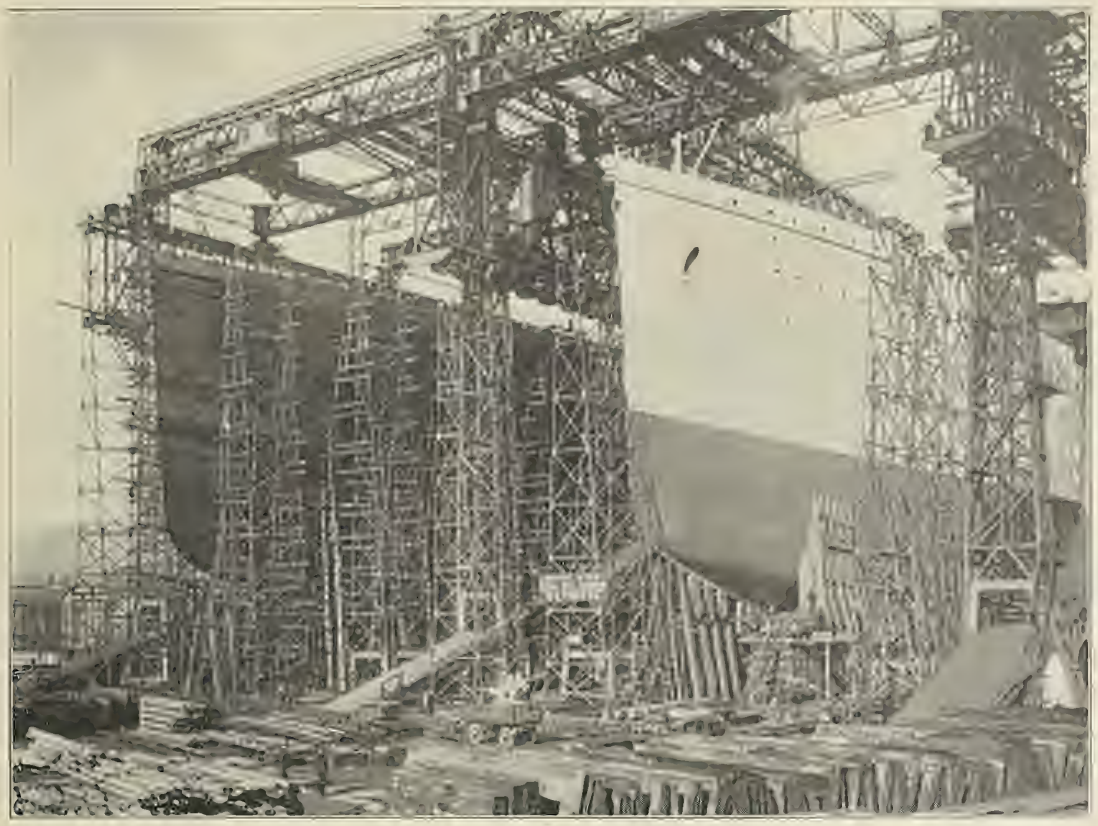
* Over all.

The *Celtic,* it may be recalled, has a sister ship, the *Cedric,* and the *Laurentic* a sister ship the *Megantic,* just as the *Olympic* and *Mauretania* have sister ships. The *Laurentic* and *Megantic* have triple-screw combination engines and the *Mauretania* and *Lusitania* have quadruple-screw turbines. The *Laurentic* and *Megantic* were built for the Canadian service and so do not mark a step in advance in the matter of size or speed, but otherwise the progress made has been continuous. In speed the White Star Line have left the field to the Cunard and other companies. Although the *Olympic* is the largest vessel ever built her size does not alter the fact that she is very graceful.

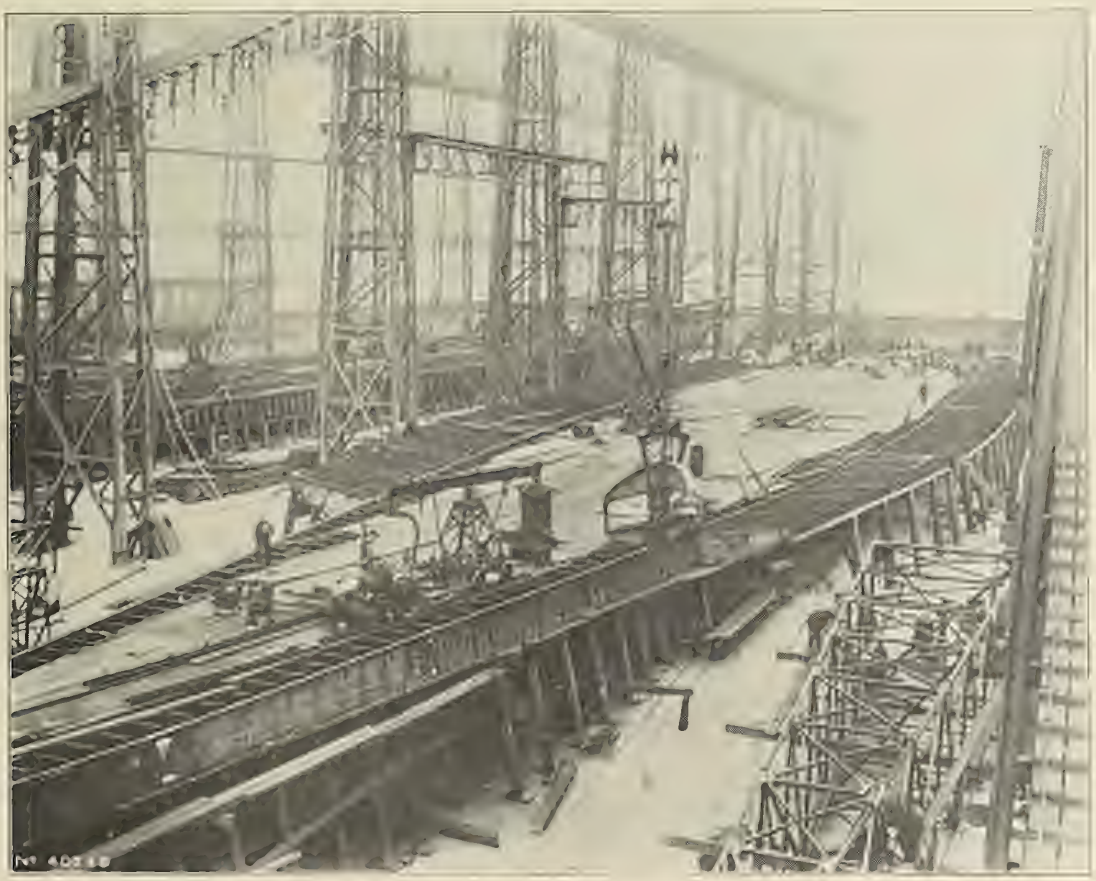


ERECTION OF FRAMING.

Besides being the largest and heaviest vessel ever launched, the *Olympic* is also the strongest. Both in design and workmanship strength has been kept in view. The most improved structural arrangements have been adopted, and every mechanical device used to secure this. The double bottom, extending the whole length of the vessel, is 5 feet 3 inches deep (increased under the reciprocating engine room to 6 feet 3 inches). The massive beams and close framing, the large shell plates, the steel decks and watertight bulkheads, combine to make a structure of exceptional strength and rigidity. The hydraulic riveting is also an important factor. The whole of the shell plating up to the turn of the bilge was riveted by hydraulic power, and also an immense amount of it in other parts of the vessel—the shell, the top sides, the decks and the stringers. The rivets were closed by means of powerful 7-ton



THE OLYMPIC AND TITANIC UNDER CONSTRUCTION AT BELFAST.



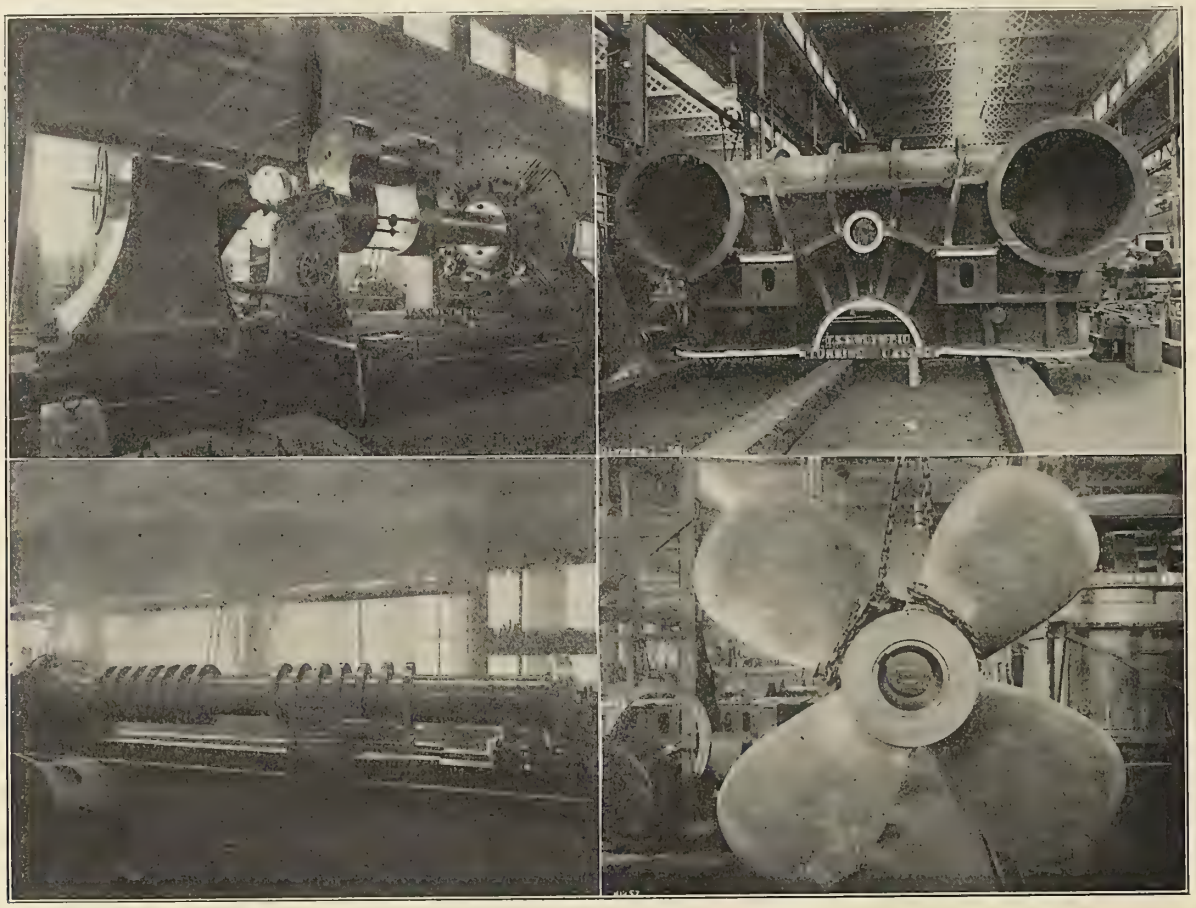
TANK TOP AND WING TANK FLOORS.

riveting machines suspended from the traveling cranes on the gantry. There are half a million rivets in the double bottom alone, weighing about 270 tons. The largest rivets are 1¼ inches in diameter. In the complete ship there are some three millions, weighing about 1,200 tons.

The largest shell plates are 36 feet long and weigh 4¼ tons each; the largest beam is 92 feet long, the weight of the double beam is 4 tons; the stern frame weighs 70 tons. The after boss arms weigh 72½tons; the forward 45 tons. The rudder weighs 100 tons; the engine crank shafts 118 tons each; the bedplate 195 tons; the columns 21 tons each; the heaviest cylinder, with liner, 50 tons; the wing propellers each 38 tons,

There will be accommodation for about 2,500 passengers, besides a crew of 860. There will be over 2,000 sidelights and windows in the ship, and the sumptuous character of the appointments will be in keeping with the traditions of the line. Both the public rooms and private cabins, and the entrances, the magnificent staircases, and other features will be on a scale of magnitude and excellence.

One of the upper decks is to be completely enclosed as a ballroom, or as a skating rink or theater, and the rest of the accommodation is on the scale of the best first-class hotels. Not only will it be possible to obtain cabin suites, but one may travel in a complete flat, comprising bedroom, sitting room or



CRANK-SHAFT.
THRUST-SHAFT.

TURBINE CASING.
TURBINE PROPELLER.

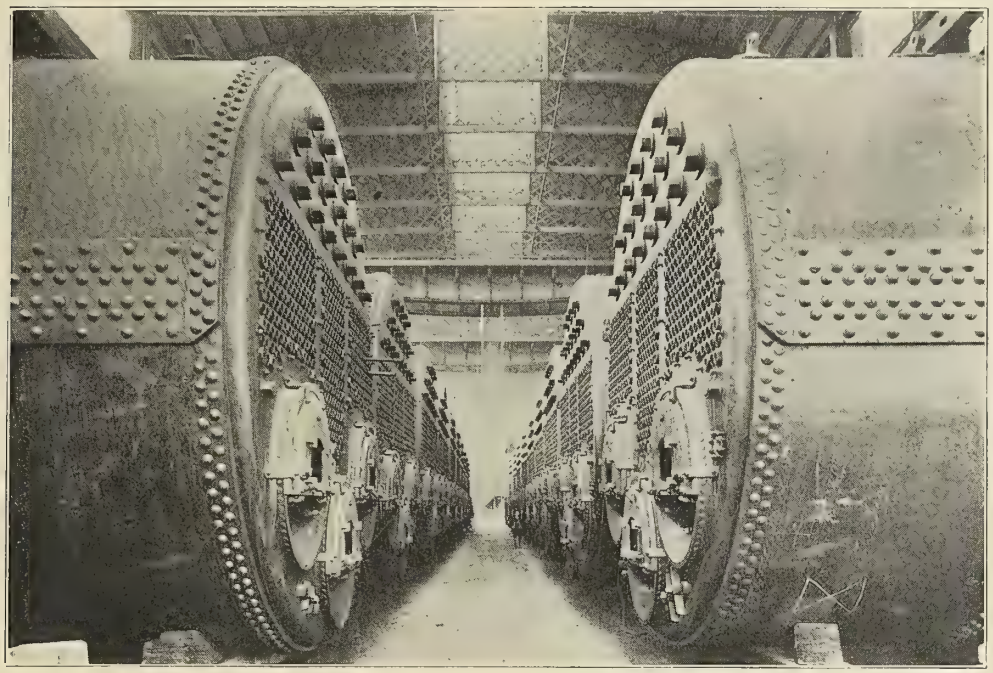
finished weights. The castings for the turbine cylinder weighed 163 tons, and that for the center (turbine) propeller, which is of solid bronze, 22 tons.

The double bottom is built with continuous frames and floor plates with intercostal longitudinals. Exclusive of the margin plates and center keelson, there are eight longitudinals, while in the machinery space special girders have been added. Above the tank top the framing of the vessel consists of 10-inch channel bars spaced 36 inches apart. This framing is lightened at the ends of the vessel, while every few frame spaces throughout the length of the hull there are heavy web frames consisting of web plates joined to the shell by double angles and reinforced at the inner edge by double angles. In the machinery space the web frames are spaced closer together than in the holds. The lower deck beams are 10-inch channels fitted to every frame and supported by four longitudinal girders. These longitudinals are in turn supported by stanchions between the decks.

The rudder is 15 feet 3 inches wide and weighs 100 tons. The diameter of the rudder stock is 23½ inches.

parlor, private baths, and even a private library, with, of course, private meals. Then for the vigorous there are cabins with private shower baths, a great swimming bath and a gymnasium, while on one of the upper decks astern there is to be a veranda café, after the manner of the open-air cafés of Southern Europe, with an orchestra and an organ to furnish music. For lady passengers a modistes' parlor and jewelery store are to be open to first and second class passengers, with a tailor's shop for the gentlemen. There are, of course, nurseries for children.

The vessel will be fitted throughout with double-banked boats, operated by the new Welin gear, the first twelve sets of which type were fitted on the new steamers recently ordered by the Union-Castle Line. The davits are of the double-acting type, each vessel carrying sixteen sets, or enough davits to handle thirty-two lifeboats, and twin frames, provided with a special arrangement for manipulating either davit arm without shifting the handle, are to be used between the boats. The outboard boats will rest on shifting chocks, extending half outboard at sea, thus leaving between the two rows of boats a



BOILERS.

clear passage of about 5 feet. All the inward boats are extras, fitted in addition to the regulation complement.

The machinery for the *Olympic* and the *Titanic* is the combination of reciprocating engines with a low-pressure turbine, the same as adopted in the White Star Canadian liner *Laurentic*. This arrangement has proved satisfactory from an engineering point of view, and, at the same time, eliminates vibration and secures comfort by smooth working of the ship.

Steam is supplied at a pressure of 215 pounds per square inch by twenty-four double-ended and five single-ended Scotch boilers, each 15 feet 9 inches diameter and 20 feet and 11 feet 9 inches long, respectively. Each of the single-ended boilers has three Morison furnaces, and each of the double-ended boilers six furnaces. The furnaces are all 45 inches inside diameter. The longitudinal seams are triple-riveted double-butt strap joints, and the circumferential seams double-riveted lap joints; the boiler heads in the steam space are stayed by eighteen through stays, the tube plates being stayed by the usual stay tubes. Each furnace leads to a separate combustion chamber, and the boilers are to be operated under natural draft.

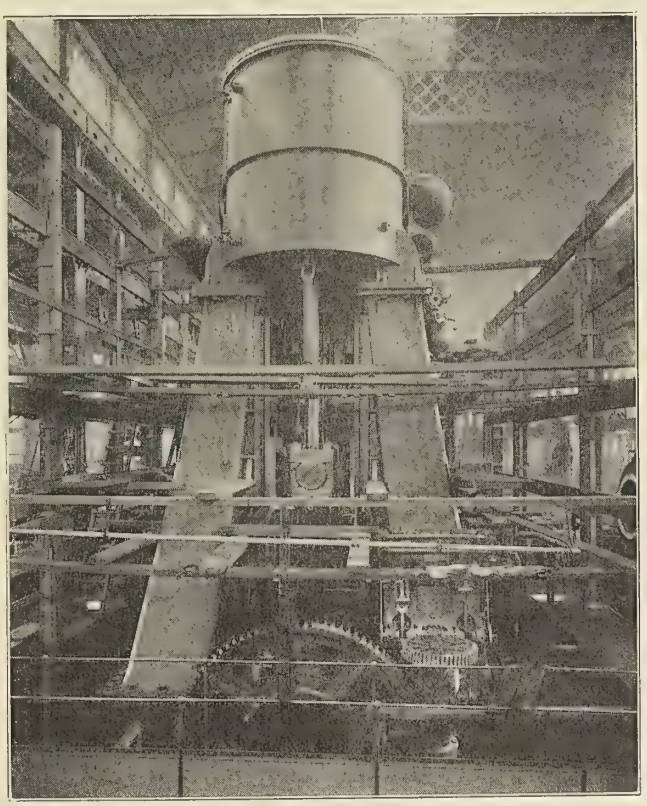
The boilers are located in six watertight compartments, the firerooms being athwartship. The products of combustion are led to three stacks, 24 feet 6 inches by 19 feet by 160 feet high, above the grates. A fourth stack is provided for ventilating purposes and to take care of the products of combustion from the galleys. The stokeholds are ventilated by Sirocco fans, two being located in each fireroom.

Coal is stored in 'thwartship coal bunkers between the boilers and a reserve supply is carried in side bunkers between decks. See's ash ejectors are fitted for use at sea, and Campbell's ash hoists for use in port.

The boiler arrangement is designed with special reference to economy and safety, since the auxiliary machinery for port use is supplied with steam from a single boiler room, but by means of connections to the other boiler rooms certain boilers in each compartment can be used for this purpose. This would enable the operation of the auxiliary machinery in event of flooding part of the boiler space.

Propulsion is by the combination system of reciprocating engines and low-pressure turbine, the three-shaft arrangement being adopted with two four-cylinder, triple-expansion reciprocating engines on the wing shafts and a single Parsons turbine on the center shaft. The reciprocating engines are located in a separate compartment just aft of the boiler space. The turbine, together with the condensers and part of the auxiliary machinery, is located in a separate compartment immediately aft the reciprocating engine room.

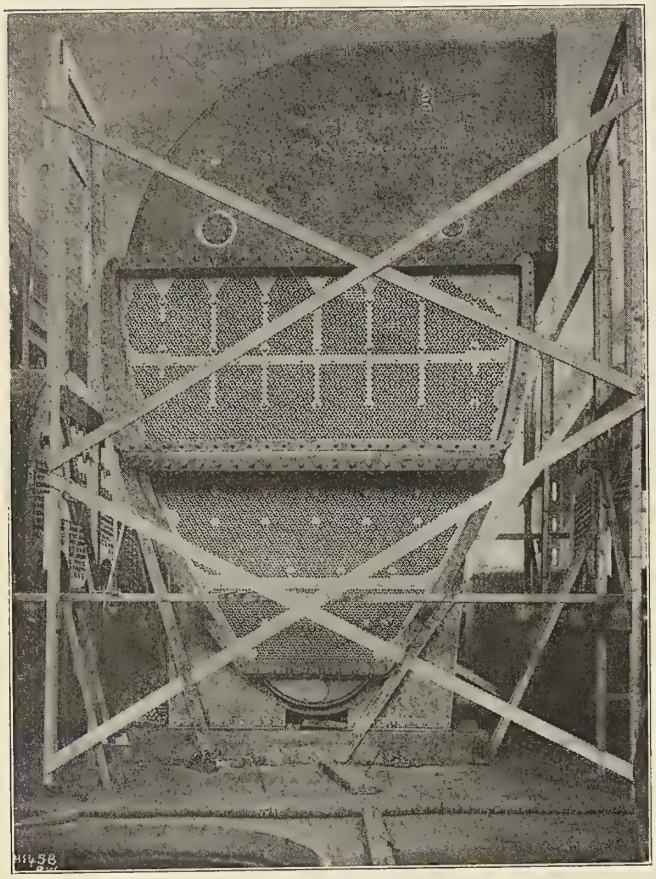
The reciprocating engines have cylinders 54 inches, 84 inches, 97 inches and 97 inches diameter, with a stroke of 75 inches. There is a low-pressure cylinder at each end of the engines, with the high-pressure and intermediate-pressure cylinders be-



STARBOARD ENGINE.

tween, the high-pressure being forward of the intermediate-pressure. The high and intermediate-pressure cylinders are fitted with piston valves, one for the high and two for the intermediate, and the low-pressure cylinders with twin slide valves. All the valves are operated by the Stephenson double-bar link motion.

The crank shafts are 27 inches in diameter, the thrust shaft



PEAR-SHAPED CONDENSER.

is also 27 inches in diameter and has a bearing in the center of the thrust block. The propeller shafting is 26¼ inches diameter, and the tail shaft 28½ inches. The wing propellers are 23 feet 6 inches diameter, and are designed to run at 75 revolutions per minute.

The turbine which receives the exhaust steam from the low-pressure cylinders of both reciprocating engines is of the latest Parsons design, the rotor being 12 feet in diameter and 13 feet 8 inches long. The turbine shaft is 20 inches in diameter and the tail shaft 22½ inches. The turbine propeller is a solid manganese bronze four-bladed wheel, 16 feet 6 inches diameter, designed to operate at 165 revolutions per minute.

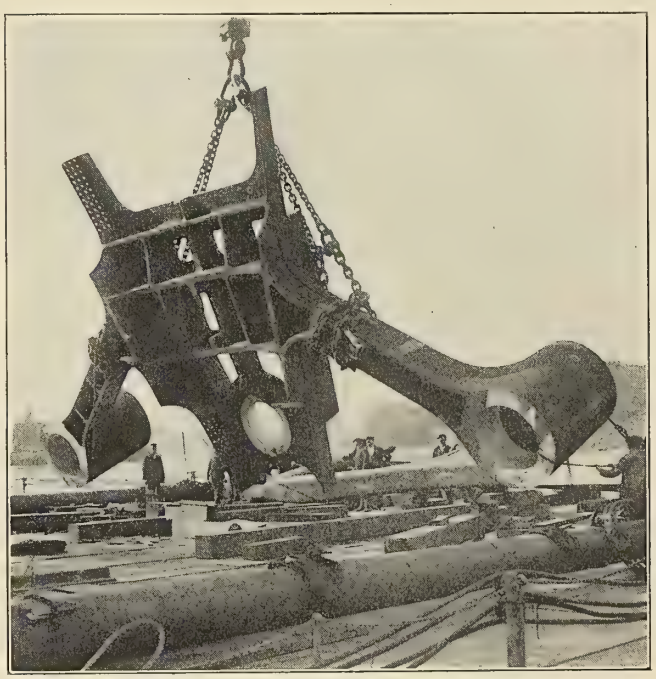
There are two main condensers of the inverted pear-shaped type, such as are usually constructed by Messrs. Harland & Wolff. This type of condenser brings the largest volume of cooling surface at the point where the exhaust steam enters the condenser, therefore making the most efficient disposition of the condensing surface. Centrifugal circulating pumps, driven by compound reciprocating engines, are installed, and the air pumps are of Weir's dual type.

An elaborate refrigerating installation, consisting of two horizontal duplex CO_2 machines, is located on the port side of the reciprocating engine room.

The electrical plant consists of four sets of 400 kilowatts capacity each, placed aft of the turbine engine room. These are supplemented by two sets of 35 kilowatts capacity, each located on one of the upper decks above the load waterline for use in case the main generating plant should be damaged or flooded in a collision.

The launch of the *Olympic* brings the tonnage of the White Star Line up to 418,907 tons, a fleet remarkable for its efficiency and modern character, including twin-screw and triple-screw steamers of the latest type, and one fine sailing ship, employed in the important work of training officers.

The exceptional size of the *Olympic* involved the construction of a new graving dock in Belfast to receive her, and the deepening of the Victoria Channel, at an estimated outlay of $146,000 (£30,000), to permit her safe outlet from and inlet to the harbor. She, with her sister ship the *Titanic*, called for the construction of special slips, three of the previously largest at Queen's Island being converted into two and piled and strengthened to such an extent that they are capable of supporting no less than 70,000 tons. It was also necessary to erect a double gantry (one of the most striking features of the port), 840 feet long, 105 feet wide, in each of the two berths, and 220 feet in height at the tallest point of the cantilever crane. The gantry is equipped with cranes and traveling frames, capable of lifting loads from 5 tons to 40 tons, and is supplied with special stagings, platforms and electric cranes. There was also the necessity of providing, at great



AFTER BOSS ARMS.

cost, the floating crane which will transfer the boilers to the new ship, of reconstructing several sections of the works on an extensive scale, of designing and fitting up a considerable quantity of special plant, and of carrying out a variety of alterations in the works to enable the builders to complete their gigantic undertaking. The outlay involved in the building plant of the new liners means an aggregate expenditure of between $1,950,000 (£400 000) and $2,200,000 (£450,000).

The Belfast Harbour Board had to make elaborate arrangements for the safe launching of the *Olympic*. They spent $292,000 (£60,000) before the works undertaken were completed. These works included the deepening of Victoria Channel to a depth of 32 feet at a cost of $146,000 (£30,000), the provision of an embankment opposite the entrance basin of the new graving dock, a suitable turning basin for the vessel, the laying of a tramway to the deep-water wharf to carry material

for the fitting out of the liner after she is launched, and the dredging of the river at the slip where the *Olympic* was built. A depth of 50 feet had to be reached opposite the berth for the plunge of the liner's stern before her bow reached the water. In addition Harland & Wolff spent over $48,670 (£10,000) in strengthening Victoria Wharf, which is situated at the entrance to the *Olympic* berth, so as to avoid any danger of its collapse when the vesel reached the water. Special arrangements were made for the launching of the vessel. To prevent the launching ways yielding under the immense weight, two cradles were riveted to the hull and launched with the ship. At the bow two hydraulic jacks, with a lifting capacity of 1,000 tons each, were placed and were brought into use just a few moments before the actual time of launching.

The keel of the *Olympic* was laid on December 15, 1908, and the framing was completed on November 20, 1909. The *Titanic* is completely plated and will be launched in about six months. It is hoped that the *Olympic* will be ready for her trials in July. Both ships will be employed on the Southampton-New York service.

TEST OF A BABCOCK & WILCOX MARINE BOILER.

The following abbreviated abstract, governing bids and contracts for watertube boilers, built for naval purposes, explains the reason for certain exhaustive boiler tests having been performed recently with boilers intended for United States vessels.

"*Guaranteed Boiler Efficiencies.*—Accompanying all bids. ..... there will be required specific guarantee of the evaporative efficiencies of the boilers proposed when burning coal at the rate of 15, 25, 35 and 40 pounds per square foot of grate surface per hour.

"At the highest rate of combustion the rate of evaporation from and at 212 degrees F. must not be less than 11 pounds of water per hour into dry steam per pound of combustible. * * *."

In pursuance of an established practice, and in accordance with foregoing requirements with respect to the boilers contracted for and now building by the Babcock & Wilcox Company, Bayonne, N. J., for the U. S. S. *Arkansas* and *Wyoming*, a boiler of a type similar to the boilers to be used was thoroughly tested out recently at the works of the company.

The boiler tested was of the following dimensions:

Grate surface..... 57.8 square feet
Heating surface..... 2,755 square feet
Length of grate..... 7.00 feet
Width of grate..... 8.27 feet
H. S.
——— 47.7
G. S.
Steam pressure..... 210 pounds per square inch

A board of officers consisting of Commander C. W. Dyson, Lieutenant-Commander John K. Robison and Lieutenant H. C. Dinger, was appointed by the Secretary of the Navy to conduct and control the tests carried out by the contractors.

The boiler was erected in a test house adjoining the power house. All necessary appurtenances and instruments for carrying on the test were arranged for. These consisted of forced-draft blower, feed heater, feed and weighing tanks, platform scales for weighing the coal, air pressure gages and pyrometers, and Orsat gas analysis apparatus, calorimeter, thermometers, etc. All necessary calibrations had been performed before the test was undertaken. The blower for supplying the forced-draft discharged at the floor line at the back of the boiler and against a baffle which deflected the air upward. The main steam pipe had connection both to the steam main of the powerhouse and to the atmosphere through a muffler. A Reilly feed heater was installed for heating the feed water, a branch pipe leading to it for supply of the necessary steam. The pressure was regulated by a valve in the steam connection to the heater. A steam connection from the main steam pipe led to a jet in the smoke pipe for the purpose of creating artificial draft.

The smoke up-take led to a stack 19.6 square feet of cross-sectional area and 100 feet in height above the grate. There were placed in the feed pipe close to the boiler thermometers for obtaining the temperature of the feed water. Nitrogen-filled thermometers were located in the up-takes to obtain the temperature of the gases of combustion.

A Barrus throttling calorimeter was located in the main steam pipe, about 18 inches from the boiler. The temperature of the steam from the boiler and at the escape from the calorimeter was ascertained by the usual arrangement of upper and lower thermometers.

The pressures of the gases in the first and third passes was ascertained by inserting tubes connecting to an air gage through the dusting doors communicating with said parts of the boiler. For the gas analysis an Orsat apparatus was used. The gas samples were taken from the up-takes through a small pipe leading to the Orsat.

The coal was weighed on platform scales placed in the air lock. Each barrow contained an even weight of 200 pounds of coal. An estimate was made of the amount of coal on the floor at the end of each hour.

The water used in the boiler was taken from the city main. The arrangement for weighing the amount fed to the boiler consisted of two tanks mounted on platform scales and placed directly over a rectangular feed tank, into which the contents of the weighing tanks were dumped after the weight had been ascertained. The boiler feed pump had a suction from the feed tank, the discharge being led through the feed heater to the boiler. The actual amount of water was checked at the end of each hour.

The moisture of the steam generated by the boiler was figured from the following formula:

$$Q = \frac{.48\ (T - t)}{L} \times 100, \text{ in which}$$

Q = percent of moisture,
T = calibration reading of the lower thermometer,
t = test reading of the lower thermometer,
L = latent heat of steam at boiler pressure.

The moisture in the coal was determined by laboratory tests from samples taken for each test.

Ash pans were cleaned at the beginning of each test. Shortly before the end of each test the fires were cleaned and brought to a condition as nearly as possible to that at its beginning.

THE TESTS.

In all six tests were made, the first four being those required by the contract, namely, at the following rates of combustion: 15, 25, 35 and 40 pounds of coal per square foot of grate per hour. Each test was of twenty-four hours' duration.

The fifth test was for the maximum capacity of the boiler and continued for three hours.

In the sixth test the rate of combustion was 45 pounds per square foot of grate per hour, the grate at the back end then being 6 inches lower than during the previous tests.

The alternate method of starting and stopping the test was employed in the first test, but in all succeeding tests the flying start was employed. All data were taken simultaneously by

representatives of the company and by one of the board and the assistants to the board.

Hand-picked Pocahontas coal of excellent quality was used in all of the tests.

PRINCIPAL RESULTS.

On test No. 1, burning 15 pounds per square foot of grate per hour, the rate of evaporation from and at 212 degrees F. per pound of combustible was 12.15 pounds of steam. The blower was not run and the boiler compartment was open. The weather was warm and clear.

On test No. 2, burning 25 pounds, the evaporation was 12.07 pounds. The steam jet in the stack was partly open, and the blower was run to ventilate the fire room, but the compartment was open. The weather was clear.

On test No. 3, burning 35 pounds, the evaporation was 11.77 pounds. The steam jet was partly open, the forced-draft blower was run and the compartment was closed. The weather during this test was cloudy and rainy.

On test No. 4, burning 40 pounds, the evaporation was 11.89 pounds. The forced-draft blower was in operation and the compartment was closed. The weather was rainy during the first half of the test, then clear.

The evaporation for all these tests is figured from and at 212 degrees F., and is based on pound of combustible.

During test No. 5, at the maximum capacity, or at about 70 pounds per square foot, the temperature of the water in the boiler was 102 degrees, the furnace was primed and fires lighted at 9:04 A. M.; steam formed at 9:12 A. M.; steam pressure 100 pounds at 9:18.92 A. M.; 200 pounds at 9:19.75 A. M. The steam jet was wide open on the smokestack and the forced-draft blower working giving a pressure of about 3½ inches of water in boiler room. The rate of evaporation from and at 212 degrees F. per pound of combustible was 10.33 pounds.

On test No. 6, burning 45 pounds coal per square foot of grate, the evaporation from and at 212 degrees F. was 11.3 pounds.

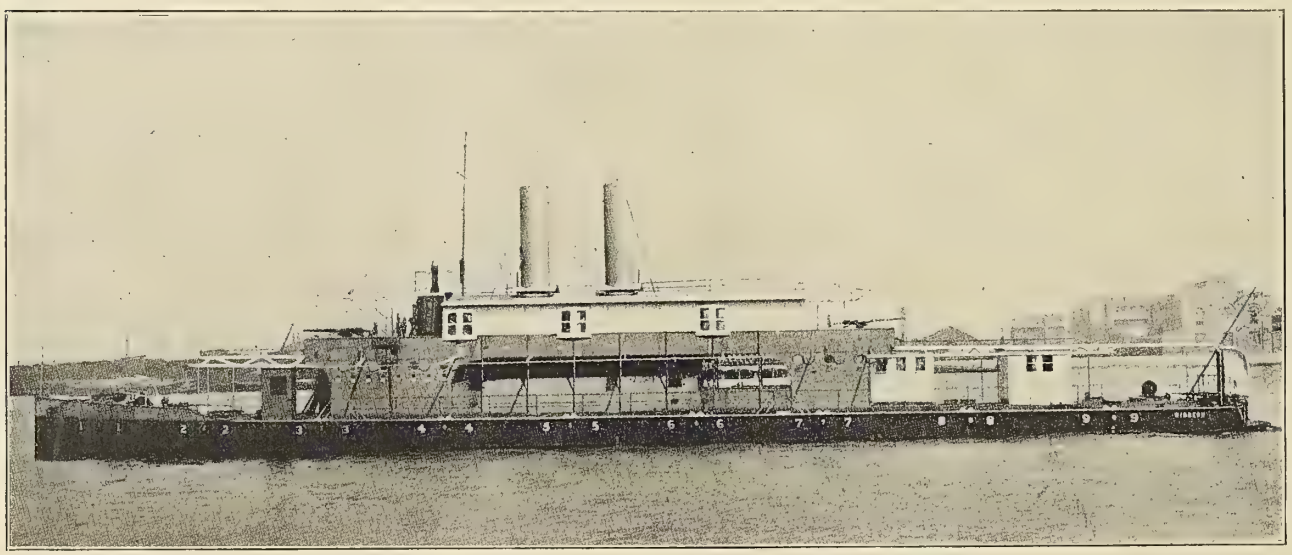
The coal used in test No. 4 analyzed as follows:

Moisture, 1.06 percent	dry
Volatile matter, 20.96 percent	21.18 percent
Fixed carbon, 74.83 percent	75.63 percent
Ash, 3.15 percent	3.19 percent
Sulphur, 0.7 percent	0.71 percent
Heat value, 15,225 B. T. U.	15,388 B. T. U.

Upon the completion of the tests the boiler was examined and found in good condition.

SHALLOW-DRAFT GUN BOAT WIDGEON.

The shallow-draft gunboat *Widgeon,* built for the British Admiralty by Messrs. Yarrow & Company, Glasgow, comprises two features which are unique with the builders. In the first place, she is a screw-propelled boat, having the propeller installed in a tunnel fitted with Yarrow's patent hinged flap for regulating the efficiency of propulsion according to the conditions of load. Second, the boat was built in sections, each section being flotable, so that the various sections could be united while afloat after having been shipped to their destination. This system of construction eliminates the necessity of erecting the boat on shore and of launching it. The construction of shallow-draft boats in flotable sections was first introduced by Messrs. Yarrow & Company in *Le Stanley,* built for His Majesty the King of the Belgians for the use of the late Sir H. M. Stanley on his journey up the Congo in 1883, and has since been extensively adopted in boats of this type.



TWIN-SCREW, SHALLOW-DRAFT GUNBOAT BUILT IN FLOATABLE SECTIONS.

The *Widgeon* is 160 feet long with a beam of 24 feet 6 inches. The steel work of the hull is galvanized throughout, the officers' quarters are on the main deck and the crew's quarters on the battery deck. Above the battery deck is a teak sun deck with double awnings. The sides of the machinery space, magazines, officers' quarters, battery deck and conning tower are all protected by bullet-proof steel plates, those around the cabins being loop-holed for rifles. The armament consists of two 6-pounder quick-firing guns and four rifle caliber Maxims. The draft of the vessel complete, when carrying a load of 40 tons, is less than 29 inches.

The machinery consists of compound engines and Yarrow watertube boilers. The boilers are fitted for burning either wood or coal, and on the trial trip, when a mean speed of 13.15 knots at 283.4 revolutions per minute was obtained, the fuel consumption proved to be 8 pounds of wood per indicated horsepower per hour.

Trials made to ascertain the effect of the patent movable flap over the tunnel showed that the horsepower with the flap raised and with the flap lowered was practically constant, but that the slip when the flap was down was augmented about 25 percent.

NOTES ON THE ARMAMENTS OF BATTLESHIPS.*

BY SIR WILLIAM H. WHITE, K. C. B., F. R. S., D. SC., D. ENG., LL. D.

One fundamental idea has governed the armaments of war-ships in all ages: viz., the desire to provide means of offense which will enable a ship making an attack to put her enemy "out of action" in the shortest possible time and ensure the least possible damage to the attacking ship during the conflict. Until armor was first used for defensive purposes, about half a century ago, there was universal agreement with the doctrine that "an active and powerful offense constituted the best means of defense." Since that date this doctrine has been somewhat obscured, no doubt, by the attention devoted to improved methods of manufacturing armor, to rival systems of distributing protective materials; by the never-ending struggle between the attack and the defense—guns and armor—and by the development of under-water attacks—locomotive torpedoes and torpedo vessels, submarine mines and submarines. It may be admitted also that, under modern conditions, an active offense is no longer the only means of defense; but, on the other side, it cannot be denied that an active offense is still and always must continue to be the best means of defense. It gives the greatest assurance of victory—in other words the greatest probability of putting an enemy "out of action."

This old phrase continually occurs in descriptions of naval battles of the past; and it is no less applicable under modern conditions than it was in the days of sailing ships and smooth-bore guns, or even in that remoter period when naval warfare was carried on by galleys propelled by oars and manned by soldiers. Victory never has depended and never will depend entirely upon the destruction or capture of an enemy's ships, but upon their being brought into a condition of incapacity to continue the struggle—that is to say, being put out of action. That result may be attained in many ways, but it must be reached in some way before victory is secured. All naval history confirms this statement; it is, in short, a truism. Looking back upon the great wars of the eighteenth and beginning of the nineteenth century it is seen that ships were put out of action by the destruction of or serious damage to their means of propulsion, to their mobility and maneuvering power; by being set on fire; by slaughter of their crews; by loss of morale; by panic arising from accident or damage which prevented continued utilization of existing means of offense; by overpowering or seriously injuring the armaments, and in other ways that need not be particularized.

This statement of the case applies primarily to circumstances affecting individual ships, and it designedly omits reference to the supreme influence which naval tactics may exercise upon the result of a fleet action, or to the skill of a commander in concentrating upon a portion of the enemy's fleet an overwhelming attack. When the tactician has done his best, it still remains true that the chief aim in a naval engagement must be to put an enemy's ships "out of action" as quickly as possible, and that sinking or destruction of ships is not necessary to secure that result, although it may be an accompaniment of victory.

From the point of view of this paper, the question to be considered may be stated, therefore, as follows: What description of armament is likely to prove most effective for speedily putting out of action modern battleships, having regard to existing materials of construction, structural arrangements, armor defense, means of propulsion and maneuvering; as well as to the characteristic qualities of guns, projectiles, explosives, torpedoes and mines now available for use? In considering this question it will be assumed that, in addressing this society, there is no need to recapitulate the remarkable advances which have been made in all these features of war-ship construction during the last half century. The facts are on record, and the existing situation is well known to members.

Certain features of the problem may also be assumed to lie outside the field of discussion. It is generally agreed that future naval actions will probably be fought at longer ranges than have been adopted in the past. The main reasons for this increase in fighting range are to be found, on one side, in the development of locomotive torpedoes and the increase of their speed, accuracy and effective range; while on the other side stand no less important improvements in naval gunnery—including guns, propellants, projeciles, explosives, range-finders, sights and means of control. Nor can there be any dispute as to the fact that increase in gun-caliber in association with a constant muzzle velocity secures greater flatness of trajectory, and greater accuracy of fire, as well as superior maintenance of energy at long ranges. But when general statements of this nature are closely examined differences of opinion on practical matters are found to exist among men equally entitled to a respectful hearing, and these differences sensibly influence their choice of armaments.

LONG FIGHTING RANGE AND SECONDARY ARMAMENTS.

In regard to the probable fighting range for future naval actions there are marked differences of opinion. While all agree that it is likely to be greater than heretofore, two distinct schools of thought exist as to the minimum range likely to occur in practice. One of these asserts that an extremely long range will be chosen and maintained by commanders whose fleets possess greater speed and whose ships are armed on the "single-caliber, big-gun" principle; and it is argued that at this great range vessels so armed will be able speedily to put out of action an enemy's ships which individually carry fewer big guns, although these may also possess powerful and well-protected secondary armaments. These secondary armaments, it is urged, would be of no practical service at very long range; because of an alleged inferior accuracy (due to more curved trajectories traversed by their relatively small and light projectiles), their proportionately greater loss of energy as ranges increase, and their presumed ineffectiveness because of their lack of power to penetrate armor of moderate thickness, their alleged less proportion of hits to rounds fired, and the small bursting charges carried by their shells.

The other school maintains that, although actions may be begun at very long ranges on occasions when atmospheric conditions are favorable, average conditions of weather at sea will not favor that kind of attack nor make its results decisive. They give reasons for the belief that when an issue is joined, with the full intention to reach a decisive finish, it is practically certain that closer ranges will be reached; and they insist that the choice of armaments ought not to be governed by a set of assumptions which relate exclusively to extreme ranges and are subject to the continued efficiency of comparatively delicate sights and range-finders as well as apparatus for controlling gun-fire. In their judgment it is desirable to associate with big guns a powerful secondary armament of quick-firing guns, adequately protected and so placed as to be efficient both in horizontal command and in height above water, while free from interference arising from independent firing of heavy guns.

In support of this advocacy of good secondary armaments it is stated that modern types of battleships, including those on which armor defense has been most developed, still contain many vulnerable points, injury to which will seriously

* A paper read before the Society of Naval Architects and Marine Engineers, New York, November, 1910.

interfere with the fighting, maneuvering and steaming capability, the transmission of orders from conning-towers and control stations, signaling and other operations which considerably influence fighting efficiency. It is noted that more than one-half of the length of heavy guns is permanently exposed and unprotected. Cases have occurred in action where these unprotected portions have been injured, the heavy guns having been put out of action by the fire of light guns which were impotent at the fighting range against armor of moderate thickness. It is also maintained that the small height above water to which the hull armor rises, and the large unarmored areas of the sides above water, must involve serious risks to a considerable number of recent battleships should they be subjected to attack by a large number of 6-inch quick-firing guns using high-explosive bursters and common shell. The "volume of fire" obtainable from such quick-firing guns would, it is considered, inflict great damage to the thin steel-plating above the armor, and so permit considerable quantities of water to find access to the interior of the ship above the protective deck, although the hull armor was left intact. Such an entry of water might seriously prejudice stability or produce objectionable "list" and change of trim, even if it did not pass below the protective deck; but there would also be the danger of large quantities of water finding its way into hold spaces and there accumulating.

These anticipations of trouble, of consequent reduction of stability, loss of maneuvering power, diminished speed and lessened mobility, are treated by the other side as unlikely of fulfilment. In support of this view it is urged that, although at short or moderate ranges the 6-inch gun makes good practice and scores a high percentage of hits to rounds fired in comparison with the percentage attained by larger guns, yet at long ranges the percentage of hits to rounds becomes compartively small. Consequently it is considered that injuries of the kind assumed to be produced by the fire of secondary armaments are not likely to be either serious or extensive. There is obviously room for difference of opinion in regard to such matters and the proper method is to trust to experience when attempting to reach a decision. When tested on a proof ground, with guns and targets fixed and ranges known, the percentage of hits to rounds fired will undoubtedly become greater at long range as the caliber of guns is increased. These conditions, of course, do not represent those which would occur in a sea fight, between fleets or between single ships, moving rapidly in relation to one another, and commonly in circumstances which will be accompanied by rolling or pitching of the gun platforms. It is not possible in peace time to imitate all the conditions of war; in particular the disturbing influences which necessarily arise when a war-ship is fired at by an enemy while making an attack cannot be represented. But there is in existence a considerable body of information based upon "battle-practice" at long ranges. These facts have not been published in detail nor are they likely to be. The writer has, however, been assured by naval officers of great experience possessing full and accurate information of this kind, who have carefully analysed results of firing at very long ranges, that the percentage of hits to rounds fired obtained with 6-inch guns under service conditions at sea compares favorably with and is not inferior to the percentages obtained with guns of larger caliber. Furthermore he has good reason for the belief that actual trials do not confirm the objection raised to "mixed" armaments on the ground that the simultaneous discharge of guns of different calibers must be accompanied by diminished efficiency in the control of fire and in the proportion of hits to rounds made by guns of different calibers. If these conclusions be true—and the writer is convinced that they are so—then it is unquestionable that even at long ranges the secondary armaments of battleships will be capable of delivering a "hail of fire" against an enemy and of exercising an important influence on the result of an action.

Published accounts of naval engagements during the Russo-Japanese War also emphasize the importance attaching to attacks made by efficient and well-handled secondary armaments carried by Japanese ships. It is probable that the deep-laden condition of Russian ships at Toushima tended to increase sensibly the prejudicial effects of fire from the lighter guns of the Japanese fleet; but after making full allowance for this feature it appears proven that considerable danger must always attend the extensive damage to unarmored superstructures which quick-firing guns of moderate caliber can inflict even at long range. What the "volume of fire" from such guns involves in damage done to signaling apparatus, control appliances and the general working of a ship in action, Captain Semenoff has graphically described. What it may do in making ships unmanageable or in temporarily destroying the command of maneuvering capability was demonstrated at Toushima and in the battle of August 10, 1904, off Port Arthur. Under the terrible hail of projectiles and of fragments of shells containing high explosives it has happened, and will happen again, that a "joint in the harness" is discovered and the ancient story of the "bow drawn at a venture" is repeated. The Japanese authorities, who may be supposed to have all the facts of the war in their possession, and who are certainly capable of analysing them, and drawing therefrom lessons for guidance in future practice, have never departed from the use of powerful secondary armaments. Personal conferences with leading Japanese authorities on naval matters enable me to say that they attach the utmost importance to the association of such armaments with guns of large caliber. In fact the trend of naval opinion throughout the world during recent years has been against the perpetuation of the system which discarded all guns except those of large caliber and 3-inch guns for use against the attacks of torpedo vessels. Consequently there is a danger of appearing "to flog a dead horse" by further advocacy of secondary armaments on this occasion, and no more need be said thereupon.

As to the most suitable numbers and calibers of guns making up the secondary armaments of modern battleships little need be added. There are obvious objections to the employment of many calibers, each requiring special ammunition and making separate control desirable. In some ships guns of 6-inch, 4.7-inch, 3-inch and smaller calibers have been mounted. Such a multiplication of calibers appears both unnecessary and objectionable. Probably the explanation is to be found in an intention to use guns from 4.7-inch downwards as an active defense against the attacks of torpedo vessels, and to supply 6-inch guns as auxiliaries to the 12-inch guns in action. The writer has long advocated a simpler arrangement which, in his judgment, would fulfil all requirements, and ventures to quote remarks on this head made at the Institution of Naval Architects a few months ago:

"The ideal armament, to my mind, is that which embodies a certain and not an extravagant number of heavy guns associated with a considerable battery of 6-inch guns. It does not seem to me a difficult matter to supply these 6-inch guns with ammunition which shall be efficient when used against attacking torpedo vessels. If anything in addition to such a secondary armament of 6-inch guns is wanted I should say "man-killing" guns capable of very rapid fire might be used for sweeping the decks of torpedo vessels; they could be placed and fought in almost any position and would require only shield protection."

Twenty-six years ago the writer, in conjunction with the late Lord Armstrong, worked out a design for a vessel in which ammunition of the special kind mentioned was provided for guns of 5-inch to 6-inch caliber for use against torpedo

craft. It has been reported recently that experiments have been made with shrapnel fired from 12-inch guns as a possible means of repelling torpedo attacks. If this be true the principle advocated has been carried to an extreme which will not commend itself generally, but the experiments constitute a virtual confession that 3-inch guns are not sufficiently powerful to deal effectively with modern torpedo vessels. That view of the matter has been confirmed by the adoption of 4-inch and 4.7-inch guns instead of 3-inch in ships of recent design; while 6-inch guns are now commended for defense against torpedo vessels in quarters where 3-inch guns were advocated four or five years ago as the only auxiliary armament required. The compass has been "boxed" in a very short time, and without any war experience to justify the change of opinion.

The main reason for preferring a caliber of about 6 inches is that experience proves projectiles of about 100 pounds weight to be the maximum which can be "man-handled" continuously and rapidly; while accuracy of fire even at long range can be combined with rapidity of discharge and remarkable effectiveness against the lightly armored, unarmored and vulnerable points of war-ships. Personally, I have always maintained the view that these quick-firing guns, their crews and the supplies of ammunition should have a remarkable amount of armor protection against the fire of similar guns carried by an enemy. In designs for which I was responsible more than twenty years ago, in which the earliest 6-inch quick-firing guns were mounted, such protection was provided. Nothing that has since occurred has shaken that conviction, and my opinion remains fixed that the secondary armament should be not merely available for use in repelling torpedo attacks but should be used in battle and be regarded as a valuable auxiliary to the heavy guns. The disposition of the 6-inch guns should be of a character that will effectively fulfil both these functions. It is not difficult to secure that result in designing war-ships, and to place the 6-inch guns so that they shall not be hampered or interfered with by the fire of the heavy guns, provided that the number of the heavy guns carried in a ship is not made excessive.

THE NUMBER OF HEAVY GUNS TO BE MOUNTED.

Turning to the consideration of what constitutes a reasonable number of heavy guns for the principal armament of a modern battleship, it will suffice on this occasion to restate the writer's conclusions and to briefly summarize the reasons therefor. These conclusions are admittedly open to debate and other views may be maintained on the basis of solid argument. The case is necessarily one for compromise, and therefore for difference of opinion as to the best course to be pursued.

There are two positions for heavy guns which, by common consent, confer supreme advantages and are always utilized. These positions are at the center line of the deck; one commanding right-ahead fire, with large arcs of horizontal training reaching well abaft the beam on each side; the other possessing corresponding command right astern and over large arcs of training reaching well before the beam. Until the Michigan and South Carolina were designed it was the general practice to mount one or two heavy guns—two in nearly all cases—in each of these positions. Superposed turrets were tried in some cases, and 8-inch guns were mounted in the upper emplacement; but this practice did not find much favor and may be considered to have dropped out of use. It was a new and bold departure in the Michigan and South Carolina to place two turrets in each of the supreme positions, and to arrange for firing the guns in one turret over the top of the other turret. That arrangement proved successful, however, and has been largely adopted in recent ships of all navies. When associated with the mounting of guns in pairs this system permits the effective use of eight heavy guns; if three guns are mounted in each turret then twelve heavy guns can be given equal arcs of command, and all the guns can be used on each broadside.

The writer has always favored and still favors the system of mounting heavy guns in pairs. French designers long preferred separate mountings for single heavy guns, and placed two gun stations amidships—one on each side. The French system was tried in the British armored cruisers *Imperieuse* and *Warspite*, and, as the result of trials, it was not repeated; the French themselves subsequently abandoned the arrangement. Twin-mountings were universally employed for a long period, and, in the writer's judgment, that plan embodies a reasonable compromise. Considerable economy is thus effected in the weight of the mountings and armor protection for a pair of heavy guns, as compared with what is needed with separate mountings for each gun; and although the risk of simultaneous disablement of two guns is necessarily incurred when they are carried on a single turntable and within the same armored station, that does not seem to be an undue risk. When three guns are mounted on one turntable and exposed to similar risks of simultaneous disablement then, in the writer's judgment, too many "hostages are given to fortune," and economy in weight of protective material and mountings has been carried too far. Actual trial will determine whether or not it is possible to maintain the same rapidity in loading and firing individual guns in a triple turret as can be obtained when two guns are mounted in one turret, and Italian naval authorities before deciding in favor of triple turrets probably satisfied themselves on this point. Italy has made many successful new departures in war-ship design, and will work out this problem thoroughly. The results will have great interest for all engaged in war-ship construction; but even if they prove satisfactory under peace conditions and as to rate of fire, only war experience can determine the crucial point as to the risk of simultaneous disablement of three guns mounted on a single turntable. The approximate allowance hitherto made for triple as compared with twin turrets is understood not to exceed an increase in diameter of about 10 percent, in some cases has been less. Obviously it would be reasonable in triple turrets to make provision for stronger armor protection and for ampler margins of strength in machinery and structure in order to meet special risks, and to render the possibility of disablement more remote. If this were done the relative weights involved in the triple as compared with the twin arrangement would be considerably increased.

In passing, one may remark that there is always a danger lest the desire to keep down weights of protective materials on heavy-gun stations should lead designers to accept relatively weakened structures and supports to armor and smaller clearances between fixed structures and revolving parts than would afford reasonable provision for safety and for continued efficiency in working when heavy blows are delivered, in action, upon the armor forming barbettes, shields or turrets. This feature in design has always received close attention in my own practice; and the dimensions and weights of structures, armor and mechanisms have not been reduced, nor have any known or probable risks been accepted, in order to minimize weight. Having regard to the vital importance of the continued efficiency of heavy gun armaments, and to the enormous weights and cost involved in installing and protecting such armaments even when dimensions are minimized, it seems preferable to err on the side of large margins of safety than to seek the irreducible minimum—the determination of which is not an easy matter, even for those most fully informed as to the results of peace experiments and past naval actions.

For over twenty years the heavy guns of most battleships

continued to be four in number, and in nearly all cases they were mounted in pairs on the center line of the deck at the two important positions above described. In connection with the introduction of the latest types of battleships—usually described as "Dreadnoughts"—a necessity arose for finding other positions for heavy guns. Ten or twelve such guns have been usually thought desirable; thirteen guns are to be carried in ships now building. Consequently three or four additional gun stations have had to be provided, and large hold spaces have been devoted to the stowage and supply of ammunition immediately below each turret. Different dispositions of heavy-gun stations have found favor, not merely in different navies, but in successive ships of the same navy. In these circumstances it becomes obvious that no fixed principles have been established or generally followed hitherto in disposing heavy-gun armaments. It is unnecessary to describe in detail various arrangements adopted in recent ships, because they are well known to members of this society; but mention may be made of certain salient features which illustrate the diversity of views that have prevailed.

In many cases history has been repeating itself; arguments which were familiar thirty or forty years ago have reappeared and have been treated as novelties. Widely differing estimates have been formed in regard to the relative importance attaching to "end-on" and broadside fire. In the earlier French disposition—in which two heavy guns were mounted forward and aft on the center line of the deck as bow and stern chasers, and two others in positions on each broadside (nearly amidships) which enabled them to be fired directly ahead or astern—"end-on" fire was treated as of equal importance with broadside fire. Three guns were available on each broadside and three guns could be fired either ahead or astern. In ships of the "central-citadel" type (designed about 1873-1878) four heavy guns were carried in two turrets which were placed *en echelon* nearly amidships, and it was possible to fire all four guns parallel to the keel, either ahead or astern. Each pair of guns had 180 degrees of training on the broadside whereon they were placed, but on the other broadside these guns had only a very limited arc of training. In these vessels, therefore, "end-on" fire was theoretically superior to broadside fire. Experience showed, however, that superstructures erected above the upper decks—primarily to limit the effect of "blast," when the guns were fired parallel to the keel-line or at large arcs of training from the beam—imposed serious limitations and disadvantages against a moving target placed nearly ahead or astern. The echelon disposition was, therefore, abandoned and a return was made to the earlier plan which mounted four guns in two commanding positions forward and aft on the middle line of the deck.

During the last five years we have seen both the old French disposition and the echelon arrangement reproduced (in principle) in new designs, only to be abandoned in later designs, in some cases before practical experience had been gained with the arrangement which was abandoned. Now there is a marked disposition to place all the heavy-gun stations at the center line of the deck, so that all the guns may be available on both broadsides. This is a return to a disposition adopted in the earliest British turret ships built nearly half a century ago. The *Royal Sovereign* (1862) and the *Prince Albert* which followed immediately after her each had four turrets so placed. It may be noted that the United States navy took the lead in this last movement, and further has the credit of demonstrating the possibility of associating powerful bow and stern fire with the maximum of broadside fire over large arcs of training, by placing some turrets higher than others and firing over the lower turrets on certain bearings.

"END-ON" AND BROADSIDE FIRE.

Advocates of "end-on" fire assert that an attacking ship which is end-on to an enemy presents to her fire a target of which the projected area (on a vertical plane) has, for its largest dimension, the extreme breadth of the ship and for its height the height of her uppermost deck; so that the chance of hitting effectively is diminished greatly as compared with broadside attack. This statement overlooks important conditions, and is therefore misleading. A ship attacking end-on must present to the fire of an enemy a horizontal target of which the greatest dimensions are the full length of the vessel, and (transversely) her extreme breadth. Consequently, errors in elevation of guns which the enemy may make are less likely to result in missing this long horizontal target than would be the case if corresponding errors were made when firing at a target of which the greatest dimension was the extreme breadth of a ship lying broadside on to the line of fire. No one can deny that the minimum of defense of vital parts of battleships—especially against "dropping" fire at long ranges—is to be found in the resistance offered by protective-deck plating, and not in the strength of vertical side armor. Nor can it be doubted that even in single-ship actions it would hardly be possible for a combatant to maintain for long the assumed "end-on" position; while in fleet actions no commander could possibly effect a similar object with a large number of ships by any conceivable tactics, if engaged against a skilful and mobile enemy. If a choice has to be made, therefore, between highly developed broadside and end-on fire it seems reasonable to give precedence to the former. This has been done in the majority of recent battleships; but it is also reasonable—having regard to great and rapid variations unavoidably occurring in the relative bearings of ships in action—to develop end-on fire to a reasonable extent. The compromise represented in the *Michigan* class now secures wider acceptance and is likely to become more generally adopted.

No difference of opinion exists as to the necessity for giving the largest possible arcs of horizontal command to the fire of heavy guns, so that in action they may be kept bearing on an enemy for the longest attainable periods as his relative position rapidly changes. When this principle is applied in working out the disposition of guns for a new war-ship one soon encounters numerous as well as serious limitations and finds that the difficulties in securing large arcs of training increase with increase in the number of gun stations. In many cases the attempt to mount a large number of guns and to give to each gun considerable arcs of training has involved serious risks of injury being inflicted on neighboring guns and their crews, when fire is delivered at or near the extremes of assumed arcs of training. Attempts are made, of course, to minimize or to prevent such risk of injury; but so-called "safety appliances" are usually of a delicate and elaborate nature and not unfrequently are intended to be automatic in action. One may be permitted to doubt whether, in the heat of action, these appliances will always fulfil their intended purpose; and it appears desirable when arranging armaments to secure practical non-interference of gun with gun, even if that course involves a decrease in the number of heavy guns mounted in a ship of given dimensions, or an increase in the dimensions of ships intended to carry a given number of guns.

In discussions of war-ship designs the relative merits are commonly assessed on the basis of what has been accomplished on particular dimensions and displacement. That method of comparison may be and often is carried to unreasonable lengths, no account being taken of the drawbacks and dangers involved in cramming many guns into ships. Freedom of action for each gun-crew, and a sense of security from interference arising from the fire of adjacent guns, are essential factors in the estimation of real fighting efficiency, even in days when the control of gun-fire from central stations is so much in vogue. Statistical statements may give to a ship so many guns and certain assumed arcs of command; but it

is necessary to consider thoroughly what would happen if these guns were fired at their assumed extreme arcs of training before a true estimate can be formed of the efficiency of an armament. The limits of really safe training are often found in practice to be considerably less than the extremes embodied in published descriptions, and the results of firing trials cause narrower limits of training to be accepted. No good purpose is served when large arcs of command exist only "on paper," and their utilization in action would involve serious risks to the structure, armament or personnel of the ships in which the guns are mounted.

OBJECTIONS TO LARGE NUMBERS OF HEAVY GUNS.

One is led to inquire, in present circumstances, whether it is possible to discover a reasonable basis for fixing the maximum number of heavy guns which should be carried by a battleship. It has been previously stated that the number of heavy guns actually carried in ships built since 1905 varies from eight to thirteen per ship, ten or twelve being carried by most ships, and the stations varying from four to six. Although it is not possible to lay down hard-and-fast rules, or to reach any general agreement, certain considerations may be mentioned which must be kept in view by all designers of war-ships. For instance, whenever heavy guns are mounted in positions near the middle of the length of a ship it is unavoidable that spaces shall be found for the installation of the magazines, shell rooms, ammunition supplies and gun-working machinery in a region mainly appropriated to the propelling apparatus and stowage of fuel. This juxtaposition of features essential to the efficiency of the principal armament and of those upon which efficiency of propulsion depend, involves considerable difficulties upon which one need not dwell. Experience on a large scale proves the need for special precautions in order that magazines may be kept cool and deterioration of the ammunition prevented; in not a few instances these magazine spaces make difficult the communications between compartments of the hold occupied by the propelling apparatus, or interfere with the efficient control and working thereof; while the arrangements for transporting coal from the bunkers to the stokeholds are rendered inferior in efficiency to those which exist in ships wherein the spaces assigned to engines, boilers, bunkers, are not broken up by magazines and shell rooms. It is also admitted that in ships which have five or six heavy-gun stations, the deck arrangements, the stowage and handling of boats and other matters incidental to every-day work and general convenience are all less satisfactory and convenient than are the corresponding features in ships where no heavy guns are mounted in the central portions of the length. In the last-mentioned vessels less difficulty is experienced in dealing with magazine temperatures, or in arranging for powerful secondary armaments, which shall be thoroughly efficient and practically free from risk of interference being caused by the fire of the heavy guns. It may be argued that these inconveniences and objections are relatively unimportant, that they have been and can be overcome sufficiently for practical purposes, and that they must be accepted in order to obtain the essential quality of a preponderating offensive power. Even if this be granted, it still remains a matter for debate whether, on the whole, it is desirable to mount ten or twelve heavy guns in five or six positions in any single ship.

The main reason advanced in favor of mounting ten to twelve guns in a battleship is that, in this manner, an overwhelming concentration of offensive power is secured. It has been the fashion in some quarters to adopt the simple method of assessing offensive power by counting the number of 12-inch guns carried. A ship carrying, say, twelve 12-inch guns has been reckoned equal to three ships each armed with four 12-inch guns even when the latter have carried in addition powerful and well-protected secondary armaments. It hardly seems necessary to deal with such a method of comparison in this paper and before this society, and it will be more profitable to state certain governing conditions to which regard must be had in reaching a reasonable conclusion on the point now under consideration.

No one questions the importance attaching to a highly concentrated attack on an enemy; but it is equally certain that, in present circumstances—as naval actions will be fought at very long range—the fire of twelve 12-inch guns carried by three ships can be as effectively concentrated on any selected point in an enemy's formation as it can be when the guns are mounted in one ship. Again, three ships armed on the *Michigan* plan could concentrate the fire of twenty-four 12-inch guns as efficiently on a selected position in the enemy's formation as could be done by two ships of the *Arkansas* class with an equal number of guns. Indeed under certain conditions the three ships might have an advantage and be capable of keeping all their guns bearing on an enemy in rapid motion longer than could be done with all the guns in the two ships; because the provision of six stations instead of four in the latter necessarily introduces greater limitations of the effective arcs of command of some of the guns than are imposed on eight guns mounted as in the *Michigan*. This latter consideration no doubt has had much to do with recent advocacy of larger calibers than 12-inch for battleships, because it is realized that the multiplication of positions and guns in a single ship is accompanied by increased interference and possibly with diminished efficiency of fire control.

That multiplication of gun positions has been necessarily accompanied by considerable increase in the length of battleships even when the protection and speeds have remained practically unchanged. As a contrast we may take the *Arkansas* with a length of 545 feet and twelve 12-inch guns as compared with the *Florida* of 510 feet in length with ten 12-inch guns. It is true, of course, that increase of speed has even greater influence on dimensions and especially on length; but it is certainly remarkable to note the construction of armored ships which are about 700 feet in length and yet carry only eight heavy guns in four positions (13.5-inch caliber) whereas only five years ago ships about 200 feet shorter carried ten heavy guns (12-inch) in five positions, and others about 250 feet shorter carried twelve heavy guns (11-inch) in six positions. Such additions to length may not be considered objectionable on the ground of diminished maneuvering power, in view of the facts that in future long-range fighting will be the fashion, that by various devices their handiness has been increased in proportion to their dimensions. On the other hand, it appears obvious that when associated in fleets vessels of this great length and high speed will require for safe handling an increase in the intervals between successive ships, so that the length of the line in proportion to the number of ships comprising it will have to be sensibly enlarged. Nor can it be disputed that this great increase in length renders greater the danger of damage from torpedo attack, even when it is recognized that with such vessels, although the commander of a fleet may intend to keep outside torpedo range, yet in action that intention may not be realized.

Under-water attacks by torpedoes, by submarines and by mines are undoubtedly among the greatest dangers to which modern war-ships are exposed, although the gun still remains the supreme weapon of offense. It is agreed that a single successful blow struck by a modern torpedo will probably produce damage which will put even the largest ship "out of action," although she may not be sunk. On this ground, therefore, it may be maintained that a limit ought to be put upon the concentration of gun armaments upon single ships, and upon the increase in dimensions and costs of individual ships; because one successful blow may, by general consent,

bring about such a serious proportionate loss to a fleet by injury to one vessel and her compulsory withdrawal from action. Moreover, many services are required from a fleet in the performance of which capacity for distributing the force is no less important than the power of concentrating it for an attack. From this point of view unlimited increase in dimensions, cost and individual power of battleships is not desirable. As to the assertion that increased steadiness of ships, considered as gun platforms, necessarily proceeds *pari passu* with increased dimensions, it need only be said that experience has proved the doctrine to be fallacious. Battleships of the modern type carrying numerous heavy guns high above water, and protected by great weights of armor, must be endowed with considerable initial stability in order to possess sufficient range of stability. As a consequence they have proportionately shorter periods of oscillation, as well as lessened steadiness under unfavorable conditions of sea. It is a matter of common knowledge also that some of the steadiest war-ships ever built have been vessels which were of small dimensions when judged by present standards. This feature in behavior, of course, is distinct from the power of maintaining speed in a sea-way; that quality is undoubtedly favored by increase in length and weight.

No claim is made that new statements of the case have been embodied in the foregoing summary of points in favor of or adverse to the adoption of battleship armaments comprising a large number of heavy guns in each vessel. All that has been attempted is to bring such points into view, fairly and briefly. Having done so the writer desires to place on record his personal opinion that in no case is it desirable to carry more than eight heavy guns in a single ship, that these guns are best arranged in four positions as in the *Michigan* class, and that they should be supplemented by a powerful and well-protected secondary armament.

INCREASE IN CALIBER OF NAVAL GUNS.

Allusion has been made to the movement now in progress for using guns of larger caliber in battleships and armored cruisers. In the United States the 14-inch gun has found favor; in Great Britain the 13.5-inch has been reintroduced; in Germany the 12-inch has been adopted instead of 11-inch. The reasons given for this departure from long-established usage may be summarized as follows:

1. With larger calibers it becomes possible to reduce muzzle velocity and to diminish erosion in the interior of guns, and yet to secure ample penetrating power against armor and superior maintenance of energy at long ranges.

2. A flatter trajectory and increased accuracy at long ranges can be obtained with guns of larger caliber.

3. Increased capacity of bursting charges can also be secured for all descriptions of shells.

4. If it be assumed that a certain total striking energy and a certain total shell-burster effect are to be obtained by one discharge of all the heavy guns mounted in a ship, then it is possible to diminish the number of guns carried if the calibers are increased, and to obtain more efficient control of fire.

All these arguments in favor of larger guns are, in principle, identical with those employed more than thirty years ago, when increase in the weights and calibers of naval guns was made with great rapidity. The arguments then prevailed for a time; and history is, in this particular, now repeating itself. At that period in the British navy we passed from 12-inch breech-loading guns weighing 45 tons and firing projectiles of 714 pounds to 13.5-inch guns weighing 67 tons and firing 1,250-pound projectiles, ending with guns of 16.25 inches caliber weighing 110 tons and firing 1,800-pound projectiles. Within a few years experience then induced a return to 12-inch guns and for a long period no larger caliber was used, but great and continuous improvements were made in guns, projectiles and explosives. Behind the reversion to more moderate calibers stood the conviction, based on actual usage and experiment, that the 12-inch caliber was sufficiently large for all practical purposes, whether armor-perforation or shell-power was considered; and that, on the whole, for a given expenditure of weight on the principal gun armament of a battleship the 12-inch gun furnished the best combination of adequate numbers and individual power. It has been stated recently that the chief reasons for abandoning the larger calibers were to be found in the difficulty encountered in making such guns or in loading and working them. As one who was intimately concerned with the matter the writer denies that these were the real causes of return to the 12-inch caliber. The subject was fully discussed by the Admiralty in 1888, when the designs for battleships of the *Royal Sovereign* class were under consideration, and it was then decided to make the change as soon as possible; but no satisfactory design for 12-inch guns was then available and consequently the 13.5-inch caliber was used once more. At the same time action was taken to obtain a new and satisfactory design of 12-inch gun, and as soon as it was available it was adopted in the *Majestic* class (1892).

Twelve-inch guns of the latest design are much more powerful weapons than their predecessors of twenty years ago; their projectiles are capable of penetrating at very long ranges the thickest hull armor fitted on the side of existing battleships. As regards armor perforation it is generally admitted that no increase in caliber is required. Although their trajectories may not be so flat as those of larger guns, practice made at sea with 12-inch guns at very long ranges is undoubtedly excellent. For the same approximate total weights of guns, ammunition, gun-mountings and mechanisms, and protecting armor it is possible to provide for five pairs of 12-inch guns as against four pairs of 13.5-inch guns. In other words, if equal rapidity of fire is assumed to be obtained by guns of the two calibers, for each ten rounds delivered by the 12-inch guns only eight rounds would be delivered from the 13.5-inch. It is improbable that in actual service equal rapidity of fire would be long maintained by the larger guns; but in any case the unavoidable uncertainties attaching to naval gunnery make the larger number of rounds fired and of hits made by the 12-inch guns a most important feature in the comparison of their efficiency with that of larger guns. For attack on the armored portions of modern battleships (as already remarked) blows from the 12-inch guns are admittedly heavy enough so that they would have a distinct advantage in this respect. In regard to shell fire, trials made against the French battleship *Jena* and against several British ironclads demonstrate conclusively that shell fire from 12-inch guns can rapidly destroy unarmored portions of battleships and can inflict great damage on the armored portions and on protective decks, provided projectiles of suitable design are used. The larger bursters possible with 13.5-inch shell—say about 40 percent greater in weight than the bursters of 12-inch shells—will undoubtedly inflict greater damage for each successful hit; but the number of such hits will be smaller unless the weight assigned to the principal armament and its protection is increased so as to have an equal number of the larger caliber guns; and that means the construction of larger and more costly ships. Fancy pictures have been drawn of wholesale damage which can be done by the explosion on board a war-ship of one common shell from a 13.5-inch gun, and of its far-reaching and destructive effects as compared with those of a single shell from the 12-inch gun. The writer has witnessed many experiments with high explosives, and knows that enormous local injuries may be inflicted by a single shell explosion. Yet he ventures to doubt the accuracy of much that has been written both as to the vastly greater relative power of 13.5-inch shells and as to the absolute necessity for

adopting guns of that caliber in order to secure effective shell fire. Without assuming the rôle of a prophet he is of opinion that just as history is now repeating itself in regard to the adoption of larger calibers, so in the course of a few years it is likely to repeat itself by a return to more moderate calibers as experience is gained and extended firing trials are made with the larger guns now being introduced. All the reasons given above for preferring the 13.5-inch caliber to the 12-inch would apply also to an argument in favor of still larger guns; and it may happen that, before the tide turns, larger calibers than 14-inch will be again mounted just as was done thirty years ago. But the turn will doubtless come in due course and for the same reasons as before.

OLD TRANSATLANTIC STEAM LINERS.*

BY FRANCIS B. C. BRADLEE.

After the *Savannah* the first ocean-going steamers constructed in the United States were the *Lion* and the *Eagle,* two wooden side-wheel vessels, built by Jacob Bell at New York, in 1841, for the Spanish navy. They were about 154 feet by 30 feet by 14 feet 6 inches, with side lever engines (these particulars are taken from Morrison's History of American Steam Navigation), and these steamers were superintended during construction by the late Mr. E. K. Collins (the founder of the Collins line of steamers), and the Spanish Government was so much pleased with his work that it afterward sent him a service of plate.

In 1842 the steamer *Bangor* (built in 1833 for the Boston and Bangor, Maine, line, about 160 feet long, and fitted with a "crosshead" engine) was sold to the Turkish Government and sent across the Atlantic to Constantinople, leaving Boston August 16, 1842. She was in the service of the Porte for many years.

In 1845, the late Robert Bennett Forbes, of Boston, so long known for his connection with American shipping interests, built two wooden auxiliary screw steamers for the trans-Atlantic trade; the *Massachusetts* and the *Edith.* The former was somewhat the larger, being about 750 tons register, 178 feet long and 32 feet broad. Her machinery was designed by John Ericsson, and built by Hogg & Delamater, New York. The engines had two cylinders, 25 inches in diameter, working nearly at right angles to each other; the coal consumption was said to be only 9 tons, and the speed, in fair weather, about 7 knots. The shaft had the peculiarity of passing through the stern, at the side of the stern post, under a patent of Ericsson's. The propeller (also on Ericsson's principle) was 9½ feet in diameter and could be hoisted when the ship was under sail. For some reason or other, however, auxiliary steamers have never been popular, and the *Massachusetts* had made only one or two voyages between New York and Liverpool when she was chartered by the United States Government to carry troops to the Mexican War (1846), and was later brought into the naval service and known as the *Farralones.* The *Edith* never was in the trans-Atlantic service at all, and we believe was also bought by the United States Government.

The continued success of the Cunard Line brought forth the feeling in America that the United States should have a line of trans-Atlantic steamers of its own, and in 1845 Congress passed a bill authorizing the Postmaster-General to solicit proposals for the transportation of mails to foreign countries. The first outcome of this was the formation of the Ocean Steam Navigation Company, who were to run a monthly line between New York and Bremen via Southampton, the subsidy being $200,000 (£41,000) per annum. At the outset, despite this large subsidy, there was so much doubt in New York regarding the success of the undertaking that most of the capital had to be raised in Bremen, and we believe that, although under the American flag and with its ships manned by Americans, this line was more under German than American control.

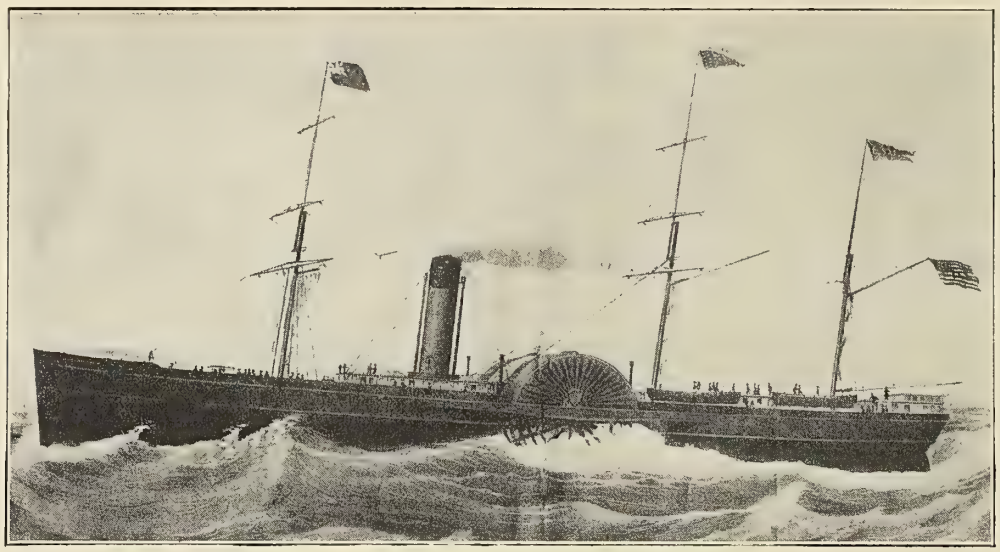
Two wooden side-wheel steamers were built at New York by Westervelt & Mackay for the Ocean Line: the *Washington* (which opened the service in June, 1847) was 1,700 tons gross, 236 feet long, 39 feet beam, 31 feet depth of hold; the *Herman* was slightly larger. The engines of both ships were exactly alike; constructed at New York by Stillman & Allen, of the side-lever type, with two cylinders, each 72 inches in diameter and 10-foot stroke. The paddle wheels were 35 feet in diameter, and at first great trouble was experienced with the machinery, the paddle wheels being too large and the boilers too small. As regards speed, the *Washington* and *Herman* were a disappointment; in 1851-52 (according to Stuart's Naval and Mail Steamers of the United States) their average passage to and from Southampton was about 14 days. They continued on the line until the end of 1857, when they were withdrawn and sent elsewhere. The *Washington* was

NEW YORK AND HAVRE STEAM NAVIGATION COMPANY'S FRANKLIN (1848).

* Continued from the October issue.

broken up in 1863 and the *Herman* wrecked on the Japanese coast in February, 1869. At this time, and until 1869, the postage from the United States to England was 24 cents per half ounce and 48 cents per ounce, newspapers at 3 cents each.

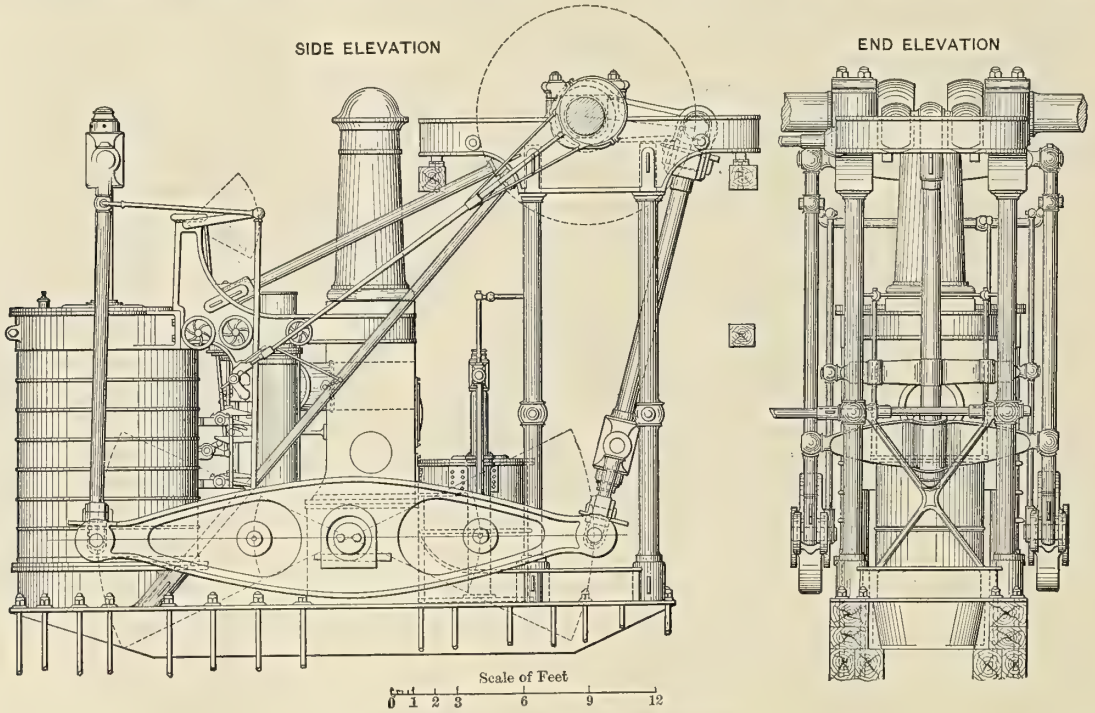
The New York & Havre Steam Navigation Company was established in 1848 by Messrs. Fox & Livingston to ply between New York and Havre via Southampton, and obtained a contract from the United States Government to carry the mails, for which they were to receive $150,000 (£31,000) per



COLLINS LINE STEAMER BALTIC (1850).

William H. Webb, in 1847, built for Messrs. C. H. Marshall & Co., the owners of the celebrated Black Ball Line of packet ships for the New York and Liverpool trade, the steamer *United States,* of 2,000 tons burden, 256 feet long, 50 feet beam, 30 feet depth, which in April, 1848, sailed on her first

annum for a monthly service. Two vessels were built for this line in New York: the *Franklin* and the *Humboldt.* The former resembled the Bremen Line ships before mentioned, and the latter was built with a straight stem and more or less on the model of the Collins boats. The *Humboldt* was



SIDE LEVER ENGINE OF STEAMSHIP ARCTIC.

voyage to Liverpool. She made several voyages, including one between New York and New Orleans, but did not pay, and was sold to the Prussian Government, who made her into a steam frigate. The *United States* had the usual side-lever engines of that day and was the first merchant steamer constructed in this country to be of use as a man-of-war. She could be armed with two tiers of guns and had plenty of room in which to work them.

2,850 tons gross, 292 feet long, 40 feet beam and 27 feet depth of hold, with side-lever engines having two cylinders, each 95 inches in diameter, 9 feet stroke; the *Franklin* was somewhat smaller, with much greater breadth of beam, and both vessels were, of course, constructed of wood.

These two ships carried on the service satisfactorily until December, 1853, when the *Humboldt* ran ashore while entering Halifax harbor short of coal, and became a total loss, and

the following July the *Franklin* was wrecked on Long Island. Happily there was no loss of life in either case, and to preserve the mail contract the service was carried on with chartered steamers until the new ships, *Arago* and *Fulton*, were built to replace those lost.

The *Fulton*, which sailed on her first voyage in February, 1856, was built of live oak at New York by Smith & Denison, and was 290 feet long, 42½ feet beam, 31½ feet depth of hold, gross tonnage 2,061, with oscillating engines with two cylinders, each 65 inches in diameter, 10 feet stroke, paddle wheels 31 feet in diameter. She could accommodate 150 first and second class passengers, 700 tons of freight and 800 tons of coal. The *Arago* was of nearly the same size and dimensions, and both ships were brig rigged, with two funnels, and both were fitted with water-tight bulkheads.

While the New York and Havre ships were never very fast, they had a great reputation for comfort and safety, and so were well filled with passengers, and financially they were by far the most successful of the American trans-Atlantic lines. On the breaking out of the Civil War in 1861, the *Arago* and *Fulton* were chartered as transports by the War Department at $1,200 (£250) a day each. In 1865, after the war was over, they were put back on the New York and Havre route, calling this time at Falmouth, England, and continued there until the autumn of 1867, when they were finally withdrawn. The *Fulton* was commanded at this time by Captain Samuel Samuels of *Dreadnought* fame. She was eventually broken up owing to dry rot, and the *Arago* was sold to the Peruvian Government.

We now come to the best known of all the efforts made to operate an American line of trans-Atlantic steamers, and this was the old Collins line, whose official title was the New York & Liverpool United States Steamship Company. It was founded by Edward K. Collins (owner of the Dramatic line of sailing packets), James Brown and other New York financiers, and in 1847 they made a contract with the United States Government to carry the mails between New York and Liverpool, making 20 round voyages a year, the subsidy to be $385,000 (£79,000) per year. One of the principal conditions of this contract was that the American steamers should be larger and make better time than the existing Cunarders.

Mr. Collins and his associates, accordingly, had built at New York in 1849, four side-wheel steamships of great size and power; the *Atlantic* (which inaugurated the new service in April, 1850), the *Arctic*, by William H. Brown, the *Baltic* and the *Pacific*, by Brown & Bell. They were built, in the heaviest and most substantial manner, of white and live oak strengthened by diagonal iron straps. The main keelson under the engine was of white oak and yellow pine and measured 22 inches in width and 42 inches in depth, but even this was not strong enough to withstand the "racking" of the engine being constantly driven at full speed. The Collins steamers inaugurated, too, several novelties; one of these being a kind of telegraph communication between the bridge and the engine room, there being several handles on the bridge marked respectively, "ahead," "astern," "stop," etc., which, when pulled, uncovered cards in the engine room bearing the same words. There was a system of bells on the same principle between the passengers' staterooms and the stewards' pantry. The passenger accommodation was considered sumptuous, including bath and smoking rooms, until then unheard of on steamers. All four steamers were at first bark rigged, but about 1854 their mizzen masts were removed, leaving them brig rigged.

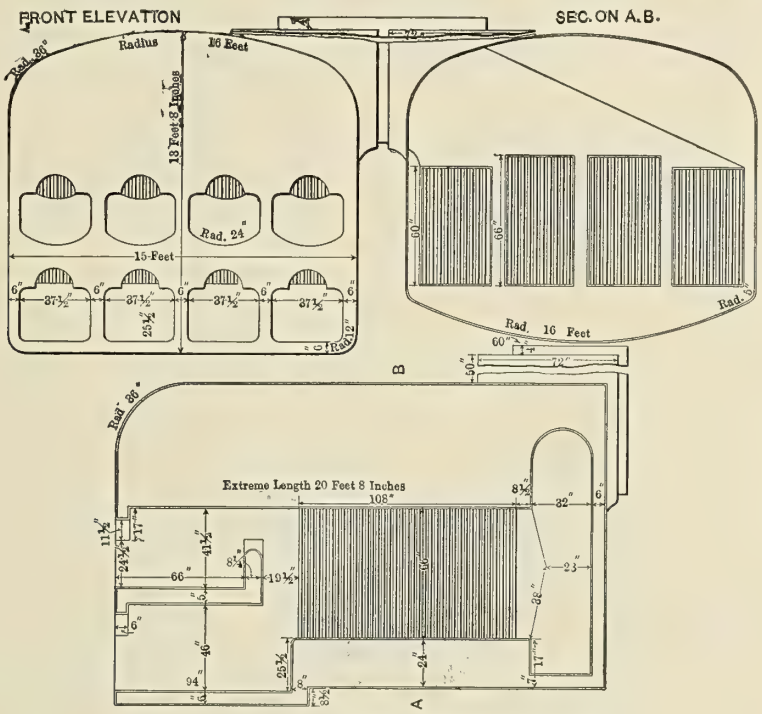


DIAGRAM OF BOILERS OF COLLINS LINER ARCTIC (1850).

The following description of the *Baltic* by Captain McKinnon, R. N., and published in Littells' Living Age for 1853, will apply equally to the other three vessels, the only difference between them being that the *Atlantic* and *Pacific* were two feet shorter than the *Baltic* and *Arctic*, and their piston rods had one foot less stroke:

"The American steamship *Baltic*, belonging to the Collins line, was built by Jacob Bell of New York at a cost of $710,000 (£145,000). She is barque-rigged and can spread about the same quantity of canvas as an ordinary sloop of war. Her dimensions are as follows: Length, 283 feet; breadth, 45 feet; depth, 32 feet, tonnage (gross), 2,723. She has a straight stem and three full decks, and with 1,100 tons of coal, 600 tons of freight, and with full complement of passengers and baggage she draws about 22 feet of water. She can accommodate 167 first class passengers and 38 second class. She is fitted with two side-lever engines, built by the Allaire Works, of New York (the Collins engines were all designed by John Farron,

engineer-in-chief of the United States navy), having 96-inch cylinders and 10 feet stroke; there are four tubular boilers, with two rows of furnaces, carrying steam at a pressure of 17 pounds to the square inch (the horsepower was 800 nominal and about 2,300 indicated), giving a speed at sea of from 12 to 13 knots on a coal consumption of from 80 to 87 tons per day. The highest speed she ever made at sea is 15 knots, and the least run for 24 hours, last winter, 167 nautical miles. I am only doing justice to these magnificent vessels in stating that they are, beyond any competition, the finest, fastest and the best sea boats in the world. I am sorry to be obliged to say this, but as a naval officer I feel bound in candor to admit their great superiority. Their extraordinary easiness in a sea cannot fail to excite the admiration of a sailor; I never beheld anything like it.

"There was none of that violent plunging—that sudden check usually attending a large ship in a heavy head sea. The elongated bow dipped gently in when a vast, wall-sided and threatening swell appeared overwhelmingly to rush upon her. The whole fore length of the vessel appeared to sink gently down, until almost level with the water, and as gradually to rise again after passing. From a considerable experience in all classes of steam vessels besides the Cunard *America,* I advisedly assert that the *Baltic* is out and out, by long odds, the very best and easiest steamship I ever sailed in."

The great defect in the Collins ships was their engines, which, being driven to their utmost capacity in all weathers, entailed heavy expenditure to keep in repair, and the *Atlantic* in March, 1851, and the *Pacific* in August, 1853, sustained serious breakdowns at sea. The fastest passages of these steamers were as follows:

Atlantic, westward, May, 1853, 9 days, 22 hours.
Pacific, eastward, May, 1851, 9 days 20 hours' record.
Arctic, eastward, February, 1852, 9 days 17 hours' record.
Baltic, westward, August, 1852, 9 days 13 hours' record.
Baltic, westward, July, 1854, 9 days 12 hours' record.

These passages were all between Liverpool and New York direct, as none of the trans-Atlantic liners called off Queenstown until 1859. The *Atlantic* was commanded by James West, the *Pacific* by Ezra Nye (afterwards by Captain Eldridge, who was lost in her), the *Arctic* by James C. Luce, and the *Baltic,* by Captain Comstock. Gustavus V. Fox, who, during the Civil War was the energetic Assistant Secretary of the Navy, was for several years chief officer of the *Baltic.*

(To be concluded.)

NEW SOUTHERN PACIFIC FREIGHT STEAMSHIPS.

A contract for four new freight steamships was placed with the Newport News Shipbuilding & Dry Dock Company, Newport News, Va., several months ago by the Southern Pacific Steamship Company of New York. This contract was the fourth order for four vessels each which has been given the Newport News Company by the Southern Pacific Company. The same builders have also constructed two other freight and passenger steamships, the *Comos* and *Proteus,* for the same owners, thus making a total of eighteen large vessels which they have built or are building for the Southern Pacific Company. The fourteen vessels previously built were all from the same model, 390 feet long, 48 feet beam, 33 feet 9 inches depth, fitted with reciprocating machinery of 4,000 indicated horsepower, giving the ships a service speed of 14½ to 15 knots. All of these vessels are still in service in the Southern Pacific Company's fleet, except the first four built, which were sold to the United States navy during the Spanish War and converted into the auxiliary cruisers *Yosemite, Yankee, Dixie* and *Buffalo.*

The new ships, two of which, the *El Sol* and *El Mundo,*

NEW FREIGHT STEAMSHIP EL SOL, FOR THE SOUTHERN PACIFIC COMPANY.

have been completed, and the other two, *El Oriente* and *El Occidente,* are still under construction, are single-screw steel vessels of the ocean-going, hurricane-deck type, 430 feet long over all, 412 feet long on the load waterline, with a molded beam of 53 feet, a molded depth to the hurricane deck of 36 feet, and a molded depth to the main deck of 28 feet.

The hull is sub-divided longitudinally by three complete decks and a partial orlop deck forward and transversely by six watertight bulkheads and two non-watertight bulkheads, forming athwartship coal bunkers. A double bottom extends under the engine room and thrust recess, which is utilized for carrying fresh water for boiler feed. Throughout the remainder of the vessel the ordinary type of single-bottom construction is used. Above the hurricane deck are two steel deck houses, one amidships, containing the accommodations for the officers and engineers, and one aft, containing the accommodations for the firemen and seamen.

BOILERS.

Steam for the main propelling and auxiliary machinery is supplied by three double-end Scotch boilers, fitted with heated forced draft. The boilers are located in a single compartment with two athwartship firerooms. The boilers are 15 feet 3 inches diameter and 22 feet long, designed for 200 pounds working pressure. The total heating surface is 15,630 square

feet, and the total grate surface 410 square feet. The furnaces are 39 inches diameter, four in each end of each boiler. Each furnace leads to a separate combustion chamber. The boiler tubes are 2¾ inches diameter, and there are 764 in each boiler.

All boilers are connected to a common stack, and the uptakes are fitted with air-heating boxes in connection with the forced-draft system. Two Sturtevant forced-draft fans of 60,000 cubic feet capacity per minute each are installed, one in each fireroom, in a recess in the coal bunkers. Each fan discharges air to all the furnaces in the fireroom in which it is located, the air being drawn from the firerooms and discharged into ducts around the air-heating boxes. This system insures a constant supply of fresh air being drawn into the firerooms, thus reducing the temperature as much as possible—an important point for a vessel that is to ply in Southern waters.

A donkey boiler, 12 feet 6 inches diamter by 10 feet long, is also provided for port use. The furnaces of this boiler, three in number, are also 39 inches diameter, and the working pressure is 200 pounds per square inch. The heating surface of the donkey boiler is 1,541 square feet and the grate surface 58½ square feet. There is also fitted in each fireroom one 6-inch See hydro-pneumatic ash ejector, and in each after fireroom a Williamson ash-hoisting engine, with cylinders 3½ inches by 3½ inches.

COAL BUNKERS.

There is one cross-bunker located at the forward end of the machinery space, and one between the boiler and engine rooms. The space abreast the machinery casings on the lower deck is also used for coal bunkers. The total bunker capacity is about evenly divided between upper and lower bunkers, both of which are filled at New York. On the trip south to Texas coal is used from the upper bunkers, so that on the return trip only the lower bunkers are full and the upper bunkers are available for cargo. Large watertight hinged doors are fitted in the bulkheads of this upper bunker space, to make it available for cargo-carrying. Four hinged coaling ports are fitted on each side of the vessel between the main and hurricane decks. The method of coaling is from barges by means of buckets handled by coaling booms located at the hurricane deck level. These coaling booms have leads to two single drums, 8 inches by 8 inches single-cylinder coaling winches, located in the deckhouse between the engine and boiler casings. A number of square hatches are fitted in the lower deck for trimming coal from the upper to the lower bunkers. Coaling scuttles, 24 inches diameter, are also fitted in the main deck, through which coal is dumped directly into the bunkers.

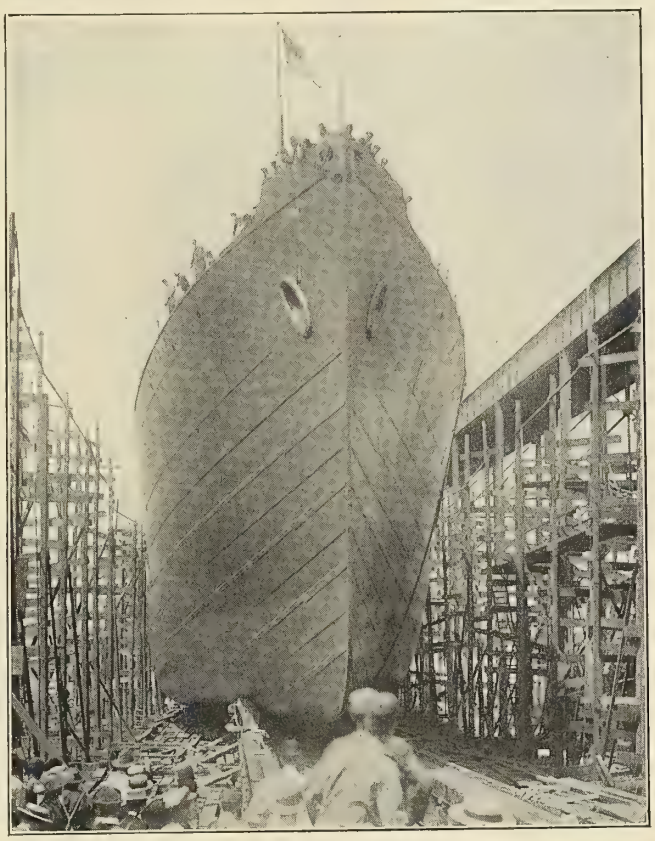
PROPELLING MACHINERY.

Propulsion is by means of a single sectional propeller wheel, with a cast steel hub and four manganese bronze blades. The propeller is driven by an inverted direct-acting triple expansion engine, having cylinders 34½ inches, 57 inches and 96 inches diameter by 60 inches stroke. Piston valves are fitted to the high and intermediate-pressure cylinders, one for the high and two for the intermediate, and a double-ported slide valve is fitted to the low-pressure cylinder. The valves are actuated by Stephenson double-bar link motion, fitted with the direct type of steam reversing gear. In the high-pressure cylinder there is a separate liner, and a cast iron piston is used. A cast iron piston is also used in the intermediate-pressure cylinder, and a cast steel piston in the low-pressure cylinder. The piston rods, cross-heads and connecting rods are forged steel. The cross-heads have double slippers of cast iron lined with white metal. The engine framing consists of cast iron housings of box section, fitted on a cast iron bedplate made in three sections. The crank shaft is of the built-up type in three interchangeable sections, and the material used here is also cast iron. The propeller shafting is of forged steel and the thrust block of the horseshoe type.

There is one surface condenser having a steel cylindrical shell, with brass tubes tinned inside and out which give a cooling surface of 9,300 square feet. Water is circulated through the condenser by an independent centrifugal pump driven by a 12-inch by 12-inch engine. The circulating water enters the bottom of the condenser and discharges at the top. The air pump is of the Edwards type and is driven together with two bilge pumps from the low-pressure cross-head.

AUXILIARY MACHINERY.

With the exception of the air and bilge pumps all of the pumps are of the independent steam-driven type, built by Blake & Knowles. There are two main feed, one donkey, one



LAUNCH OF THE EL SOL AT NEWPORT NEWS.

sanitary, one deck service and one oil pump. A Reilly feedwater heater and a Ross grease extractor are also fitted.

Electric lights are fitted throughout the vessels, the electric plant consisting of two 10-kilowatt General Electric direct-connected marine generating sets located in the lower engine room.

The deck machinery includes a Hyde steam windlass, with horizontal wildcats for handling the anchors and chains. The windlass engine also drives two warping capstans. Aft, there are two similar capstans driven by a reversible 8-inch by 8-inch double cylinder capstan engine. The steam-steering gear is of the screw type, the engine having double cylinders, 10 inches by 8 inches, controlled from the pilot house and also from the warping bridge located at the level of the top of the after deckhouse. Hand-steering gear of the right and left-hand screw type is also located in the after deckhouse.

CARGO-HANDLING APPLIANCES.

Special attention has been given to the provision of means for economical and quick handling of freight. There are four

large hatches in each of the decks, two forward and two aft. Two of the hatches on the hurricane deck are of the over-all type, which, when opened in conjunction with the cargo ports directly underneath, afford splendid openings for the mechanical conveyors which are used in handling the cargo. These hatches are each fitted with watertight steel covers in four sections, the inboard sections being hinged. The other two hatches on the hurricane deck and the four hatches on the main deck also have hinged watertight steel covers, the covers being handled by the cargo booms. On each side of the vessel, between the lower and main decks, there are four cargo ports, each fitted with watertight hinged doors, in two sections divided horizontally. There are also four cargo ports on each side between the main and hurricane decks, the watertight hinged doors for which are divided vertically. These ports are all located to suit the gangways at the Southern Pacific Company's terminals.

The facilities for handling cargo through the hatches comprise four cargo booms on each mast, two on each side. As the foremast is located between the two forward hatches, and the mainmast between the two after ones, each hatch is served by two cargo booms, one port and one starboard. Each of these cargo booms has a lifting capacity of 7½ tons and the length varies from 47 feet 3 inches to 57 feet 6 inches. Each cargo boom is operated by a single drum, 9-inch by 10-inch single-cylinder winch, located on the main deck. These winches are fitted with vertical shafts and gear for driving vertical gypsies on the deck above.

HULL CONSTRUCTION.

The framing of the vessel is of channel section, each frame extending to the hurricane deck. Both the lower and main decks are of steel, while steel stringers and tie plates are fitted on the hurricane and orlop decks. In way of the over-all hatches on the hurricane deck, heavy stringers are provided, together with two tie plates, which are rigidly connected to steel castings securely fastened to the deck on the forward and after sides of the hatches. The hurricane and orlop decks are planked with yellow pine, and on two of the vessels the main deck has a yellow pine-calked deck on top of the plating. The deck beams are also of channel section and are supported by two rows of longitudinal girders, with wide-spaced stanchions. From the keel to the load waterline the shell plating is joggled, and above the waterline it is fitted in inside and outside strakes.

ACCOMMODATIONS.

Exceptionally well-appointed accommodations are provided in these new ships for both officers and crew. The captain's and deck officers' quarters are in a deckhouse forward on the hurricane deck, the pilot house being above the officers' deckhouse, with a flying bridge located at the level of the top of the ladder. The captain's quarters consist of an office and separate stateroom finished in mahogany, with a private bath connected to the stateroom. An officers' toilet, with shower bath, is also provided in the upper house. A chart room is so located as to be accessible from all officers' rooms, and an inside stairway leads directly to the pilot house above. Quarters for the engineers, steward, petty officers, etc., are located abreast the engine casing. A separate room is provided for each engineer. These rooms all have doors opening out on the deck, and the engineers' rooms also have doors opening on passages inside the deckhouse. A bath tub is provided for the engineers and a separate shower for the petty officers.

The captain's messroom, seating eight, and the officers' messroom, seating sixteen, are located in the forward end of the lower deckhouse. The captain's messroom is paneled in mahogany, and the officers' is finished in a cherry wainscoting, with ash panels above. The galley extends the full width of the deckhouse and is located just forward of the boiler casing. Between the galley and the messrooms are the pantry, steward's storeroom and cold storage room. Separate messrooms for the firemen and seamen are located in the deckhouse at the sides of the boiler casing.

To fulfill the contract requirements these vessels must maintain an average sea speed of 15¼ knots for the round trip between New York and Galveston when loaded with 4,000 tons of cargo in addition to full water, stores, etc., the coal consumption not to exceed 1.6 pounds per indicated horsepower per hour. The *El Sol*, which was the first of the four vessels to be completed, averaged on her maiden trip over 16 knots for the round trip, the coal consumption averaging less than 1.5 pounds per indicated horsepower per hour.

THE MARINE STEAM ENGINE INDICATOR—XVI.*

BY LIEUT. CHARLES S. ROOT, U. S. R. C. S.

THE STEAM LINE.

The steam line *B C* of Fig. 95 (see September issue) shows the percentage of boiler pressure realized in the cylinder at the commencement of the stroke, and indicates how well this pressure is maintained to the point of cut-off. From the information thus obtained, we can estimate the sufficiency of the pipes, steam passages and port openings; the relative speed of the valve in closing at cut-off and the approximate position of the piston when cut-off takes place. In order that any fluid may flow from one point to another—and steam is no exception—a lower pressure must exist at the point towards which the flow takes place. This explains why the initial pressure in the cylinder is always a little less than the boiler pressure, no matter how large and straight the passage between the boiler and cylinder. The *initial pressure*, referred to above, is the pressure in the cylinder at the beginning of the stroke, and is represented by the height of the steam line above the atmosperic line at that point. *Initial absolute pressure* is represented by the height of the steam line above the line of zero pressure or absolute vacuum.

If the steam passages are of such size that the steam will have to flow at a speed greater than 6,000 feet a minute in order to supply the engine, the friction will be excessive and the pressure drop more than necessary. Other causes con-

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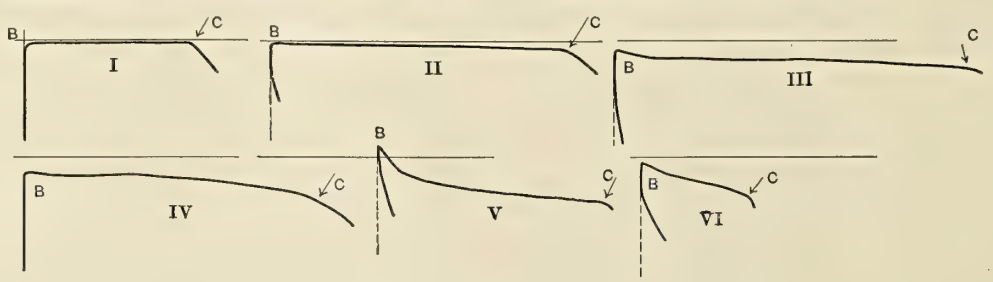


FIG. 97.

tributing to loss of pressure are stop valves, separators, short bends, contracted port opening, rough and crooked steam passages in the cylinder castings and initial condensation.

At I. (Fig. 97) is shown an ideal steam line. This is part of a diagram taken from the high-pressure cylinder of a compound pumping engine built by Geo. H. Corliss, of Providence, R. I., and fitted with the valve gear which bears his name. *B C* is the line of boiler pressure, and the steam line is within 2 pounds of and parallel to it throughout its length, showing that the pressure is constant to cut-off. The sudden drop in pressure at *C* shows that the valve closes smartly. In this engine all the conditions are favorable to good results. The steam pipe is ample and has easy bends, the cylinder ports are short and large, the piston speed is low and the valve gear is of a type which closes the valve almost instantly.

Diagram II. (Fig. 97) is another good example. This is from the 19-inch high-pressure cylinder of an 1,800 horsepower engine of a cargo steamer. The engine is fitted with a radial valve gear of the Joy type and uses superheated steam. The boiler pressure is 245 pounds gage, and the pressure at effective cut-off (*C*) is 232 pounds, or nearly 95 percent of the boiler pressure. This is an unusually good result. If the initial pressure is within 5 pounds of the boiler pressure, and the pressure at effective cut-off is within 80 percent of boiler pressure, the results are considered good in marine practice. Diagrams III. and IV. are good average steam lines from the high-pressure cylinders of marine engines. Diagram V. is from the high-pressure cylinder of a torpedo boat engine running at full power, and shows excessive lead and wire drawing. Diagram VI. is from a dynamo engine and shows the same defects.

From the ordinary diagram it is impossible to tell whether the pressure loss is due to the piping or to the valve gear and ports. To determine this it is necessary to apply the indicator to the steam chest. This is done by attaching the instrument so that it will be in communication with the valve chest and taking the drum motion from the regular reducing gear. Simultaneous diagrams should be taken from the cylinder and valve chest with the same scale spring. The diagrams will be of the same length if the ends are well stretched. Cut

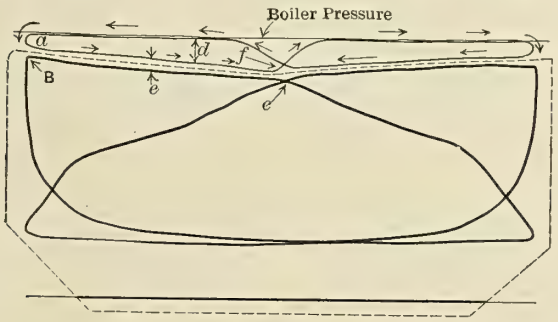


FIG. 98.

out the cylinder card, as shown in broken lines in Fig. 98, and paste it over the steam chest card, making the atmospheric lines coincide, lining them up horizontally at the same time. The valve opens to steam at *B* and the chest pressure falls at once, as shown at *a*. As the piston commences to move faster, and the heavy draft of steam begins, the pressure in the chest continues to fall, reaching its lowest amount at *f*. Cut-off occurs at *c* and the chest pressure rises again to the boiler pressure line. The indicator pencil moves in the direction of the arrows. The length of the vertical line *d* at any point represents the loss of pressure due to the friction in the steam pipe and its fittings, and the distance *e* the loss due to wire drawing in the ports and passages.

In any engine, if the steam line drops at all, the slope will be greater on the top cards, due to the influence of the angularity of the connecting rod, which causes the piston to move at its greatest speed when making the down stroke. In the intermediate and low-pressure cylinders of multiple expansion engines, the steam lines are variously affected by the sequence of the cranks, the angle between them and the points of cut-off in the several engines. In the compound engine, where the high-pressure steam line is shown at I. (Fig. 97), cut-off takes place in the low-pressure before release in the high-pressure. In this case, the steam line produced is, in reality, an expansion line, the low-pressure valve chest or receiver being a closed chamber filled with steam and with no opening, but the steam passage to the low-pressure cylinder. As the low-pressure piston advances the steam in the receiver and cylinder expands as one body, and the pressure falls as the volume increases, causing the steam line to fall, as shown at I., Fig. 99. It is evident that, no matter how ample the ports, the pressure is bound to fall.

The steam line shown at II. (Fig. 99) is from the low-pressure cylinder of a compound marine engine. In this engine

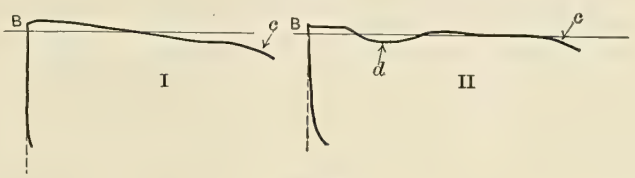


FIG. 99.

the high-pressure release is earlier and the cut-off later than in the previous diagram. The pressure falls from *B* to *d* in the usual manner. At *d* release in the high-pressure takes place, and the fresh steam injected into the receiver raises the pressure and holds it well up until cut-off occurs at *c*.

In Fig. 100 we have a diagram taken from the intermediate-pressure cylinder of a triple expansion engine. When release occurs in the high-pressure cylinder the high-pressure crank pin is at *H* and the intermediate-pressure pin 120 degrees behind it at *M*. Owing to the connecting rod angularity the intermediate-pressure piston is on the line *di*. The stroke begins with the pressure at *B*; at *d* the high-pressure exhaust blows into the intermediate-pressure receiver, raising the pressure as shown. The high-pressure cylinder, the intermediate-presure receiver and the intermediate-presure cylinder are now in communication, and by the time the

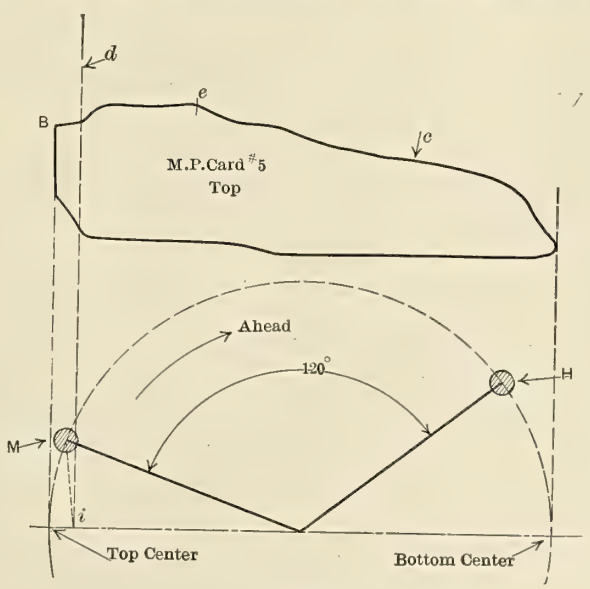


FIG. 100.

intermediate-pressure piston has reached *e*, the pressures in all three are very nearly equalized and the steam in these spaces commences to expand together as the intermediate-pressure piston advances. Cut-off occurs at *c*, but the point cannot be distinguished. Owing to considerations of weight and space, the steam ports and pasages in intermediate-pressure and low-pressure cylinders of marine engines are necessarily contracted, and steam speeds of 7,000 to 10,000 feet per minute are more common than speeds of 6,000 feet. In view of these facts, it is evident that no judgment can be formed relative to the sizes of steam ports in these cylinders without the aid of additional diagrams taken from the receiver spaces.

(To be continued.)

THE PRACTICAL OPERATION OF STEAM TURBINES AND RECIPROCATING ENGINES.

BY FRANCIS J. S. NOLAN.

The practical operation of steam turbines and reciprocating engines is at present being given a great deal of thought by shipbuilders, shipowners and marine engineers. It has taken a century to bring the reciprocating engine to its present stage of development, but the steam turbine is hardly with us ere it is installed in hundreds of ships of all classes, from battleships and ocean greyhounds down to small freighters plying round our coasts. The different types of steam turbines which have, from time to time, been brought before us have been many, but none has as yet reached such a high status in the marine world as the Curtis and Parsons turbines. Both of these types have their advantages and disadvantages, but be it said to the credit of both that in several ways they are more economical than the piston engine.

For example, take the work that has to be done when a ship fitted with reciprocating engines reaches port. I instance an Atlantic liner running the mails between England and New York.

The mail ship may take anything from four and a half to six days to make her run across; she reaches New York, and then a vast amount of work has to be begun and finished at the latest in four days. All the engine-room staff and several of the fireroom staff are pressed into service, so that the work may be got through with on time. The heavy work done in the engine room of a twin-screw Atlantic liner, when she reaches New York, is very great and includes the following: Four crank pins to be examined and have leads taken off them; four cross-heads to have the same amount of work done on them; four main bearings to be also treated in a like manner; all top plugs taken out of cylinders, pistons, junk rings and cylinder walls examined.

I will try to give in detail all the work necessary to overhaul the above-mentioned parts, in order to draw a comparison between the ship fitted with turbines and the ship fitted with reciprocating engines.

In order to overhaul a pair of cross-head brasses it is necessary to take down all the oil service pipes from the gravity oil boxes on the cylinder tops. These pipes, while down, are blown through with steam, and any foreign matter which may have lodged in them is at once removed.

From a lug cast on to the bottom of the cylinder is attached a shackle and a pair of chain blocks, the cross-head nuts are then slacked back with a spanner and ram, an eye-bolt is screwed into the steel cap of the cross-head, the blocks are hooked on the eye-bolt, and the heavy steel cap and top half of the brass are then lifted off by means of the blocks, cleaned and examined; two bits of lead wire, about 1/16-inch in diameter, are laid on the cross-head pin, the brass and cap are then again lowered into their place, and the nuts are driven hard up by means of an iron ram used on the end of a short spanner, the ram being suspended from overhead by rope slings.

The nuts having been driven up to a given mark, the spanner is reversed and the ram is brought into action on the other side of the spanner, the nuts are slacked off, and cap and brasses lifted with the chain blocks as before; should the leads prove to be too thick, then a liner, of which there are several fitted to each pair of brasses, is removed, and leads are taken once more. This process is repeated until the leads are brought to the required fineness, and then the cap and brass are replaced and tightened up for working.

We next come to the four pairs of crank-pin brasses which have to be overhauled. Two pairs of chain blocks are rigged up, one on either side of the connecting rod, the engine having been turned on the top center. The blocks are suspended by two eye-bolts screwed into holes in the bottom side of the cross-head. A heavy spanner is then placed on the crank-pin nuts, two eye-bolts being inserted into the top of the crank-pin bolts; the chain blocks are then hooked on to these eye-bolts, and a pair of rope blocks are led from a shackle in the end of the spanner to a hand winch on the engine-room bulkhead, the fall of these rope blocks is taken round the barrel of the winch and is heaved taut by two men, the ram is then brought into action on the other side of the spanner until the nut is slack enough to turn by hand. The same process is gone through with the other nut; both nuts are now screwed off the bolts, and the chain blocks now having the whole weight on them, the whole thing is lowered into the crank pit. The top half of the brass is then bolted to the bottom of the connecting rod, and strong backs are put underneath the slippers and across the guides, to take the weight of the piston, piston rod, connecting rod and brasses; the engine is then turned down and the rod swung, the top brass is cleaned and examined; the bottom half having been treated in a like manner, the engine is turned back again to the top center. The whole thing is lifted up again out of the crank pit, and leads are taken off it in the same manner as was done in the case of the cross-head brasses. This performance is repeated until such time as the leads are fine enough to give the bearing a good running surface without it being too tight.

We next come to the main bearings. The nuts are slacked back in the same manner as before, with a ram and spanner, and rope blocks led from the spanner to the winch on the bulkhead. The steel cap, which in some ships weighs as much as 20 hundredweight, is then lifted and slung to one side, the brass is then taken up, cleaned, examined, leads are put on the shaft, and the brass and cap are put down again and the leads taken off in the usual way.

Next we have all the cylinders to examine, which are eight in number in most liners which are twin-screw. Round plugs, weighing about 6 to 8 hundredweight, are fitted to the cylinder cover by means of a flange, which is cast on them, and are held in place by means of studs and nuts. The nuts having been taken off, the plug is lifted out by means of blocks and tackle. The inside of the cylinder is then examined, every junk ring bolt being sounded with a hammer, also the nut holding the piston in place is sounded for slackness, the cylinder walls are examined and usually painted with a thick coat of black oil. The examination being completed, the plug is dropped into place and screwed up, the examination takes place in each cylinder and any slack bolts or nuts are made good.

The next thing which demands the attention of those who are preparing the ship for her next voyage are the several auxiliaries, each performing its own important duties.

The electric light engine has to be overhauled. The crank-pin brasses, cross-head brasses, must have leads taken off them. The piston must be taken out and the cylinder examined, and all valve gear attended to and steam glands re-

packed. Next come two of the main circulating pumps for the main condensers, which have to receive the same amount of attention as the electric light plant. We next have a range of boiler feed pumps, six in all, two of which have to be overhauled each time the ship reaches New York. The steam chambers and water chambers are opened up and the steam piston and water bucket are drawn out and the chambers examined, all the water valves are also taken out and the worn ones are replaced by now ones, the valve gear is taken down and the shuttles examined, cleaned, oiled and put back, and new joints are made for steam and water ends where required.

All this work, as well as a host of other small jobs, is done in four days, and even in spite of all this there is a throb and vibration about the ship fitted with reciprocating engines that one doesn't get in the ship which has a turbine plant aboard.

I will now turn to the ship fitted with turbine engines. There is no heavy work to be done, all the work that is done is on the auxiliaries. In this type of ship, of course, there are more auxiliaries than in the ship fitted with reciprocating engines, the same overhauling has to be done to the auxiliaries in the turbine ships as to those in the reciprocating engined ships, but the work for the greater part is only of a trifling nature; a few steam or water joints may have to be remade and a few glands, water and steam repacked. An examination is also made of the interior of the turbines, which only entails the taking off of a few man-hole doors to gain admittance.

Several small doors are also taken off the main condenser sea-water side, so that the tubes may be inspected and any dirt which may have come thorugh the main injection and lodged in the tubes can easily be removed. In most ships fitted with turbines a turbo-generator is installed for the electric plant. This, again, does away with a lot of work which would be necessary were a piston engine fitted.

With the steam turbine the noise or vibration is hardly worth speaking of; the engine-room staff can be reduced by half that required with reciprocating engines, most of the oiling being done by forced lubrication. It has been found that in properly balanced rotors the vibration is only a very small item.

In the two types of steam turbines used to-day for marine purposes there is not much to choose. The turning effort of a steam turbine is obtained by the impulse or reaction of the steam in passing through the moving blades, and all designs embody one or more of these methods. From a mechanical and operating standpoint those turbines operated solely by impulse have a decided advantage over those operated by reaction, owing to the great clearance which can be allowed between the blade tips, and the cylinder, and the spindle. Those operated by reaction, however, have led the way in obtaining low steam consumption; and on account of this, the disadvantages of small clearances have been accepted.

From the operating standpoint the sole objection raised to the Parsons type is the possibility of the blades stripping or the dummies seizing. Should it so happen that one of the main bearings got overheated and the white metal run out, the blades on the rotor would at once come into contact with the bottom casing, and the effect, needless to say, would be disastrous to the rotor and casing alike.

In the Curtis system the steam moving at high velocity passes directly across the blades and has no tendency to pass round them; consequently, not only does all the steam that passes through the turbine do useful work, but the clearances between the blades and the casing may be made large, and the danger of contact between the two, with its disastrous stripping of blades, is avoided. The clearances in this type vary from ¼ inch to 2 inches, a smaller number of blades are necessary, construction of blading may be made much stronger, separate cruising turbines are not necessary, and the amount of power developed on the shaft is under close control.

In the reciprocating engine the rods, guides and valve fittings account for more dissipation of heat than the whole radiating surface of the cylinder. In the turbine the principal losses are internal nozzle friction, skin friction, wheel friction, and exit velocity, and, in the case of reaction machines of the Parsons type, leakage round the blade ends. Radiation from the turbine to the surrounding air is almost immeasurable, as the surface presented to the air is very much smaller, compared to the power, than in the case of the reciprocating engine. It is also easier to insulate the turbine thoroughly, not only because of the simplicity of lagging and the absence of externally moving parts, but because of the absence of large bodies of metal, such as guides, rods, etc., leading from the steam chamber to the unlagged cool parts.

Leakage over the tips of the blades is perhaps not so detrimental in the Parsons type on account of actual leakage loss as in its superheating effect on the steam, the row past which it leaks and the last row, which, it is well known, seriously affects the fluid efficiency.

The trouble with the stripping of blades may be set down to bad workmanship, defective blade material, whipping of spindles due to bad design, or bad balancing, and to the excessive cylinder distortion due to differences in temperature. This last has been found to be the most fruitful cause, and is a really serious one, being due entirely to poor design. It has been found that great care must be taken in proportioning the cylinders; for under wide ranges of temperature, when the turbine is working, there may be a fall of from 400 to 150 degrees F. in a distance of 5, 6 or 8 feet. The radial expansion, therefore, is greater at one end than at the other. It has, therefore, been found that a good clearance is necessary.

In most ships fitted with turbines it has been shown that only below 45 percent its full speed does the consumption of the turbine exceed that of the reciprocating engine.

It has also been shown that the *Lusitania* is 16 to 20 percent more efficient than the greatest reciprocating plant afloat. In 1907, the *Lusitania* consumed 12 pounds per shaft horsepower, and in 1907 the *Mauretania* consumed 11½ pounds per shaft horsepower. The last figures represent about 69 percent of the energy available in the steam, and is certainly worth taking notice of, both as to where the increase in economy has taken place and what is possible in the future.

It has been found by practical test that, adding, say, 30 pounds to the steam pressure at the high-pressure receiver improves the efficiency of the turbine only a little and adds to the weight of the turbines.

Considering turbine machinery, further reductions in weight cannot be expected until some great advance is made in the development of high-speed propellers or, *vice versa*, in the discovery of some type of turbine more suitable for low-speed running than the present patterns. The turbine problem is inherently bound up in that of the propeller, the present state of compromise being the best that can now be arranged.

When the problem of reversing turbines has been solved we may expect a much further reduction in weight. The turbine requires the same auxiliaries as the reciprocating engine and a few additional ones, besides larger condensers and air pumps. There is another advantage the turbine holds over the reciprocating engine, and that is where the priming of boilers occurs. Priming is an evil which often takes place even in the best-designed reciprocating engines and turbines on board ship. The causes of priming are many, from an operating standpoint. The following have been found to be serious causes of priming on board ship: Irregular firing of boilers, a mixture of quick and slow evaporating coal, dirty boilers, and the rolling and pitching motion of a ship in a heavy sea way.

In the reciprocating engine priming is one of the worst enemies to be contended with. It is not an infrequent thing to

have burst cylinders, split cylinder covers, and bent piston rods—all the fruits of priming.

In the turbine priming is a serious malady; the water coming from the boiler may bring with it foreign matter, which may adhere to the blades, especially in the reaction type, where the blades have not got much clearance. Here, again, the impulse type gains a point. Owing to its greater clearance, it is able to clear itself much sooner of water, and the chances of stripping the blades are not so great.

ship. The double bottom is divided into 16 watertight compartments, having a total capacity of 2,500 tons of water. This will enable the steamer to maintain the best trim under any conditions of loading. There are 12 watertight bulkheads, and where it has been found necessary to pierce the bulkheads with doors, the Stone-Lloyd improved hydraulic system of closing the doors has been established. There are in all 20 of these watertight doors, which may be closed at will from the navigating bridge, either all at once or separately,

THE LARGEST FRENCH STEAMSHIP AFLOAT.

THE FRENCH LINER FRANCE.

What is destined to be the largest and speediest boat of the French merchant marine was launched September 20 from the yards of the Atlantic Works at St. Nazaire. The *France*, as she was christened, is of 23,000 tons gross and 45,000 horsepower, and it is expected that she will make the passage across the Atlantic between Havre and New York in five and one-half days. The keel of the *France* was laid April 20, 1909, on the day following the launch of the 18,000-ton battleship *Diderot*. Her construction has been somewhat delayed on account of labor trouble, so that seventeen months were required to bring her to the launching stage. It is expected, however, that she will be placed in service early in 1912. The principal dimensions are as follows:

Length over all	715 ft. 3 ins.
Length between perps	685 " 2 "
Breadth, molded	75 " 5 "
Depth to "D" deck	52 " 10 "
Depth to "A" deck	78 " 9 "
Draft, loaded	29 " 6 "
Displacement	27,000 tons
Gross tonnage	23,000 "
I. H. P.	45,000 "
Designed speed	23.5 knots

The hull is built of Siemens-Martin mild steel and special high tensile steel has been used for the superstructure. Three plates, having a total thickness of about 3 inches, were used for the keel, and the bottom of the ship is further strengthened by a double bottom worked nearly from end to end of the

as may be desired. Seven powerful steam pumps, having a total capacity of 2,500 tons of water per hour, will be able to maintain the ship afloat in case of leakage.

The machinery space occupies a length of 470 feet amidships. The remainder of the space in the hold is occupied by dynamo rooms, bunkers, cargo and parcel-post rooms and holds. The vessel has a capacity for 6,000 tons of cargo and 5,500 tons of bunker coal.

There are 8 steel decks, of which the 5 upper ones are covered with wood. Counting from the bottom, the fourth 'tween deck or "H" deck, is taken up principally by cargo and bunker space. There are also large storerooms for daily stores and refrigerating rooms for meat, poultry, fish, game and vegetables. The passengers' luggage room is also located on this deck.

The deck above, or the "G" deck, is devoted to the crew and steerage passengers. On the second 'tween deck, or "F" deck forward, there are quarters and galley for the crew; additional accommodations for steerage passengers, together with their galley and mess room. Amidships is the lower first-class dining room, also the children's dining room. Astern are the first and second class galleys and the second class dining room surrounded by second class staterooms.

The "E" deck is entirely devoted to passengers. In the forecastle are the petty officers' quarters, the infirmary and the two ships' hospitals. Then come the cabins, staterooms, dining room, smoking room and galley for the third class passengers. Amidships is the upper first class dining room and numerous staterooms. Aft are second class staterooms and close to the stern are quarters for the musicians.

The main deck, or "D" deck, is divided as follows: Forward,

is a promenade deck for steerage passengers; amidships, the space is devoted to first class passengers, including the entrance hall and other public rooms. Abaft the second group of funnels is the second class social hall and smoking room. The after part of this deck is reserved as a promenade for engineers, firemen and petty officers. The deck, both forward and aft, is fitted with the ordinary auxiliary machinery, including capstans, winches, etc. Close to the room containing the steering engines are several small storerooms.

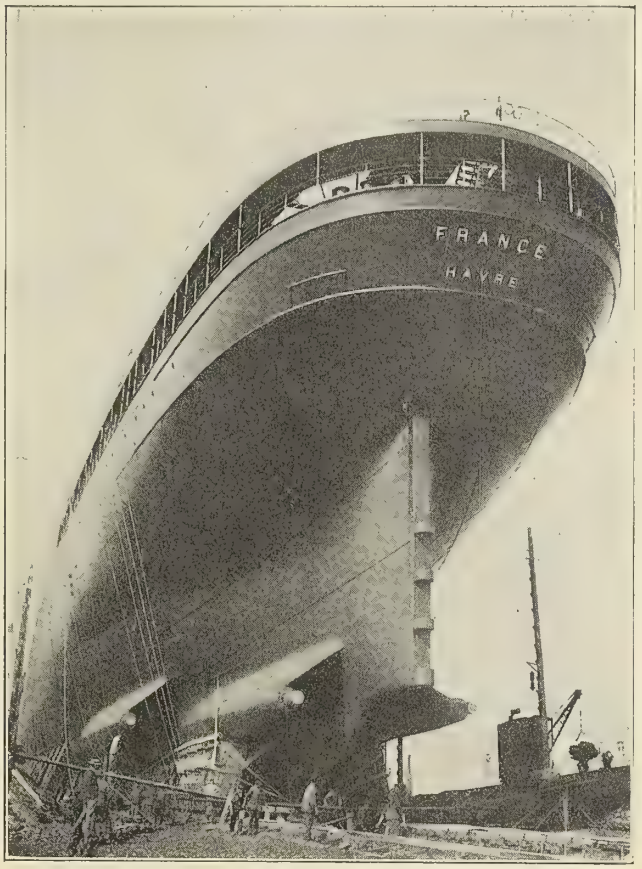
On the "C" deck are located large deck houses, in the forward part of which is a series of cabins de luxe and staterooms, also the telephone and wireless telegraph office; amidships is the main entrance for first class passengers, also the drawing, writing and reading rooms, music room, etc. The after part of this deck is reserved as a promenade for second class passengers.

In a large deck house on the "B" deck are located the officers' quarters, children's play room, library, printing office and, amidships, the social halls. Abaft the second group of funnels is a café, smoking room and open-air café or veranda.

The "A" deck is reserved as a promenade for first class passengers and will carry 20 lifeboats, each 20 feet long by 8 feet 6 inches broad, together with other smaller boats and life rafts. Welin quadrant davits are installed for handling the boats. At the forward end are the captain's apartments, and above these the chart and pilot house and flying bridge, the latter being 54 feet above the load waterline.

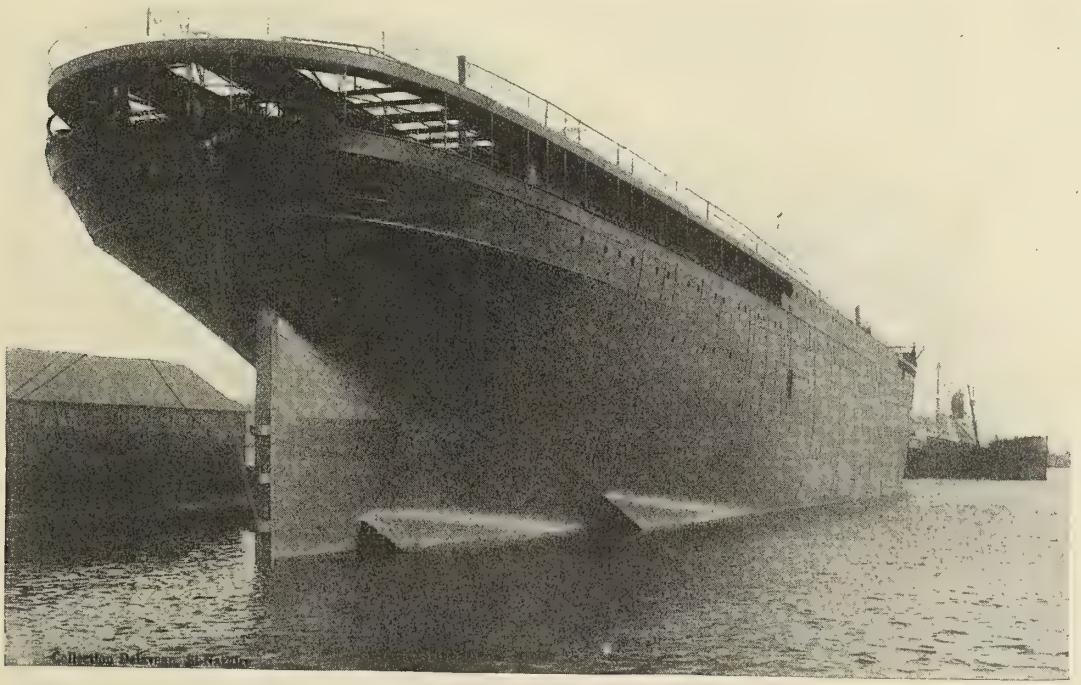
From the foregoing description of the arrangement of the vessel, it is evident that various classes of passengers will be entirely separated from each other, but special care has been given to the ventilation of all passenger accommodations, electrically-operated fans being installed throughout the ship.

Boilers of the Scotch type have been adopted, and there are 20 in all of the single and double-ended types. They are constructed of semi-hard steel and have been tested for 200 pounds normal pressure. The grate and heating surfaces are 2,600 and 10,110 square feet respectively, the ratio being 1 to 38. The boilers are divided into four groups, each having its own funnel, 112 feet high above the grate bars and 17 feet 5 inches diameter. The boilers are all operated by Howdens' forced draft system, which is maintained by electrically-driven fans.



ARRANGEMENT OF TURBINE SHAFTS WITH INCLINED BOSSING.

The main engines are of the Parsons type, and the four-shaft arrangement is employed. There are two high-pressure and two intermediate-pressure ahead turbines located in the first compartment, together with the high-pressure astern turbines, the auxiliary condenser and about half of the aux-



STERN VIEW OF THE FRANCE IMMEDIATELY AFTER LAUNCHING.

iliaries. These turbines drive the wing shafts. There are two low-pressure ahead and two low-pressure astern turbines, driving the center shafts and located in the second compartment, together with the main condensers and the remaining auxiliaries.

The turbine casings have been made of cast iron and the rotors, as well as the disks, were machined out of ingots. The blading has been carried out according to Parsons' latest improved system, with the usual method of binding. The hollow shafts are made from steel ingots. The four-bladed propellers each have a diameter of 13 feet 2 inches and have been designed for working between 220 and 240 revolutions per minute. They are of manganese bronze. The total weight of the turbines is 730 tons and of the shafting 160 tons.

The electric plant consists of four generators operating at 220 volts at the terminals, driven by steam turbines. They will supply the necessary current for 4,000 lamps, also for motors operating the winches, fans, elevators, etc. The refrigerating plant, which is of the Linde patent, has been designed to maintain a temperature of —5 degrees in the cold chambers. The crew will consist of 60 officers and deck hands, with 260 men in the engineering department and 275 in the civil department.

The builders are to be congratulated upon the successful launching of this vessel. The launching operation itself took only 45 seconds and cost $47,500 (£9,800). The total launching weight, including the cradle, was 12,100 tons, which is a record in French shipbuilding.

COLUMN TABLES FOR SHIP WORK—II.

BY R. EARLE ANDERSON.

RATIONAL FORMULAS.

It has been shown in the previous section that the commonly accepted empirical formulas are unsuited to our purpose, largely because they provide no basis for passing from one material to another. If, however, a strictly rational formula can be found which is substantiated by all available test data, it may safely be relied upon for materials for which no test data is to be had, particularly if the test data upon which it rests cover a very wide range of materials.

Such a formula has been proposed by Moncrieff (Trans. Am. Soc. C. E., XLV., 1901). His formula is cumbersome, which has probably prevented its general use, but, as already pointed out, this need not prevent its use for the preparation of tables. Moncrieff gives the most complete resumé of tests which is anywhere to be found, classifies them (failure to do which has led to some confusion in the case of other authorities) and compares his formula with each class of tests, with the result that its correctness is fairly established. There are several other rational formulæ, notably that of Prof. J. B. Johnson (Framed Structures, page 144). They do not rest upon as complete a comparison with test data as does Moncrieff's, however. Johnson's formula is very similar to Moncrieff's, and would probably give equally good results. It appears necessary, however, to consider only Moncrieff's formula, particularly as he embodies in its derivation several considerations overlooked by others and which appear to be vital. It should be stated that the Moncrieff formula here referred to is that for the ultimate strength of the column, and not for safe working load, a matter which will be discussed in a succeeding section. Moncrieff's formula is based upon the stress produced in the extreme fiber, when the column deflects under a load supposedly central, but actually eccentric. It is pointed out that no column can, except by a combination of improbabilities, be under a truly central load. There will exist in every column some eccentricity, due partly to accidentally eccentric imposition of the load, partly to geometrical eccentricity of the column, and partly to lack of homogeneity of the material owing to the methods of its production and to the fabrication of the column. All these forms of eccentricity may, for mathematical purposes, be summed up as a single eccentricity of load.

Any number of columns supposedly identical will fail under test at widely differing loads owing to the differing amount of the virtual eccentricity. The result of this is that the locus of ultimate unit strength of columns of like material and varying length ratio is not a line but an area, and inspection of of test data shows that, barring a few scattering spots which may be put down as due to defective specimens, this area is very well defined. A sufficient number of tests are plotted in Figs. 2 and 3, to show the general nature of the area.

Practically all authorities, except Moncrieff, draw their curves through the middle of this area. Moncrieff points out that the curve defining the lower limit of the area should be taken as the real curve of ultimate strength, inasmuch as no column can safely be assumed as having an ultimate strength greater than this.

He found that a curve constructed from his formula could be made to define the lower limit of the area of failure, the upper limit, or the mean, according as the value assigned to eccentricity was a maximum, a minimum or a mean.

Moncrieff's formula for the ultimate strength of a round-end column under supposedly central but actually eccentric load is

$$\frac{l}{r}=\sqrt{\frac{48E}{5f_t+p\left(\frac{ye}{r^2}-5\right)}\left[\frac{f_t}{p}-1-\frac{ye}{r^2}\right]}$$

It will be noted that the term expressing the eccentricity occurs in combination with the radius of gyration and the distance to the extreme fiber, in the form: $\frac{ye}{r^2}$

It may be noted that in several other rational formulas, which deal with the eccentricity, including Prof. Johnson's, the same fraction appears and is the only form of the eccentricity function. Prof. Lilly has derived a formula in which the same eccentricity function appears, but he has discarded the eccentricity as unimportant.

By careful comparison with test data, Moncrieff evaluated this fraction. He found that its greatest value could be taken as 0.6, and its least value as 0.15, and that these can be taken as constants, irrespective of the material and type of end. In other words, for the lower limit curve the value 0.6 can be substituted for ye/r^2 in the equation, which will still be entirely general. This allows the formula to be reduced as follows:

$$\frac{l}{r}=\sqrt{\frac{9.6\,E\,(f_t-1.6\,P)}{p(f_t-0.88\,P)}}$$

This is the formula which has been used in the preparation of the Construction and Repair Tables. The terms E and f_t are constant for any given material, allowing corresponding values of p and l/r to be found without difficulty. It may be noted that, using the same value for ye/r^2, Prof. Johnson's formula may be written:

$$\frac{l}{r}=\sqrt{\frac{9.6\,E\,(f-1.6\,P)}{p\,(f-P)}}$$

These two formulas differ only in the coefficient of p in the denominator, and the difference is trifling.

Both of these formulas assume that the elastic curve of the column is a parabola. This is the only assumption made by Moncrieff, not resting on a strictly rational or experimental basis. This parabola lies between the arc of a circle of

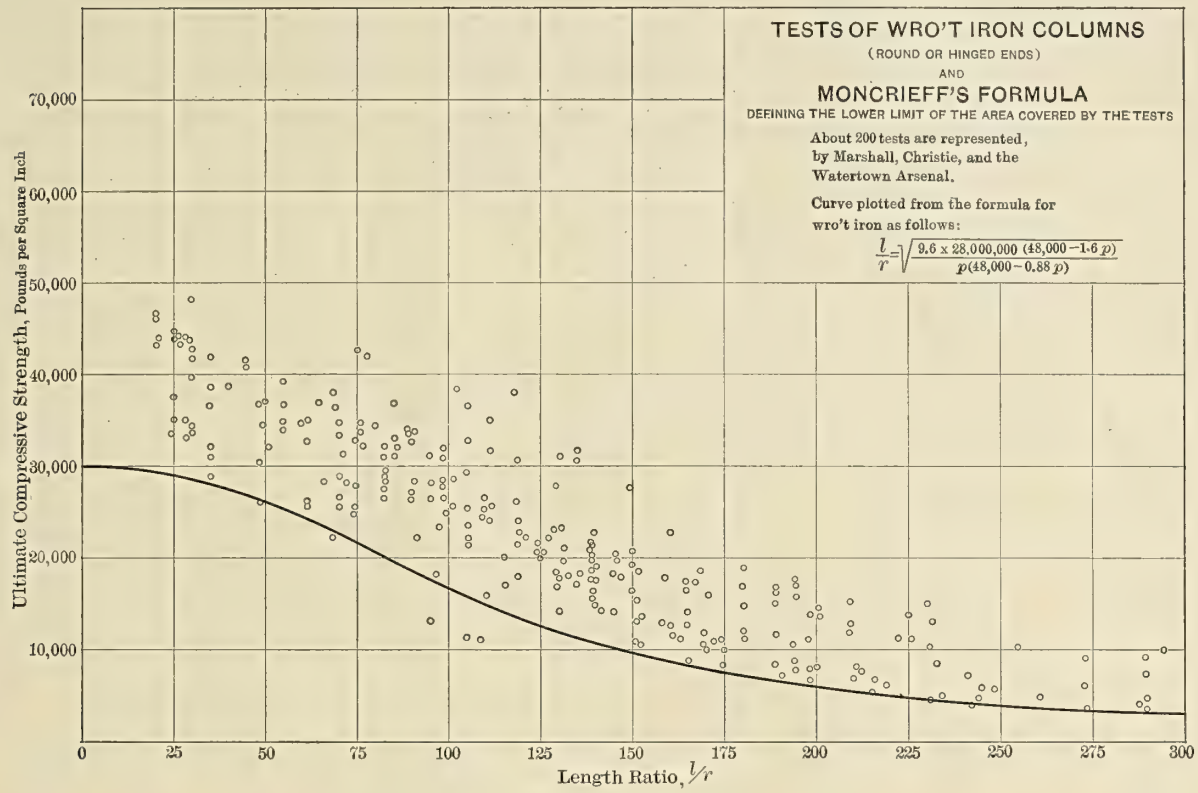


FIG. 2.

Rankine's formula and the curve of sines of Euler's. Moncrieff shows that a column must bend either to a curve of sines, to an arc of a circle, or to some curve lying between these two, and that the parabola fulfills this condition, and, as compared with either the curve of sines or the arc of a circle, involves a possible error not exceeding 2.73 percent; this error, if it exists, is on the safe side.

Since Moncrieff's formula gives the relations due to stressing the extreme fiber to a definite amount (the ultimate strength), it is true for failure by crushing on the intrados.

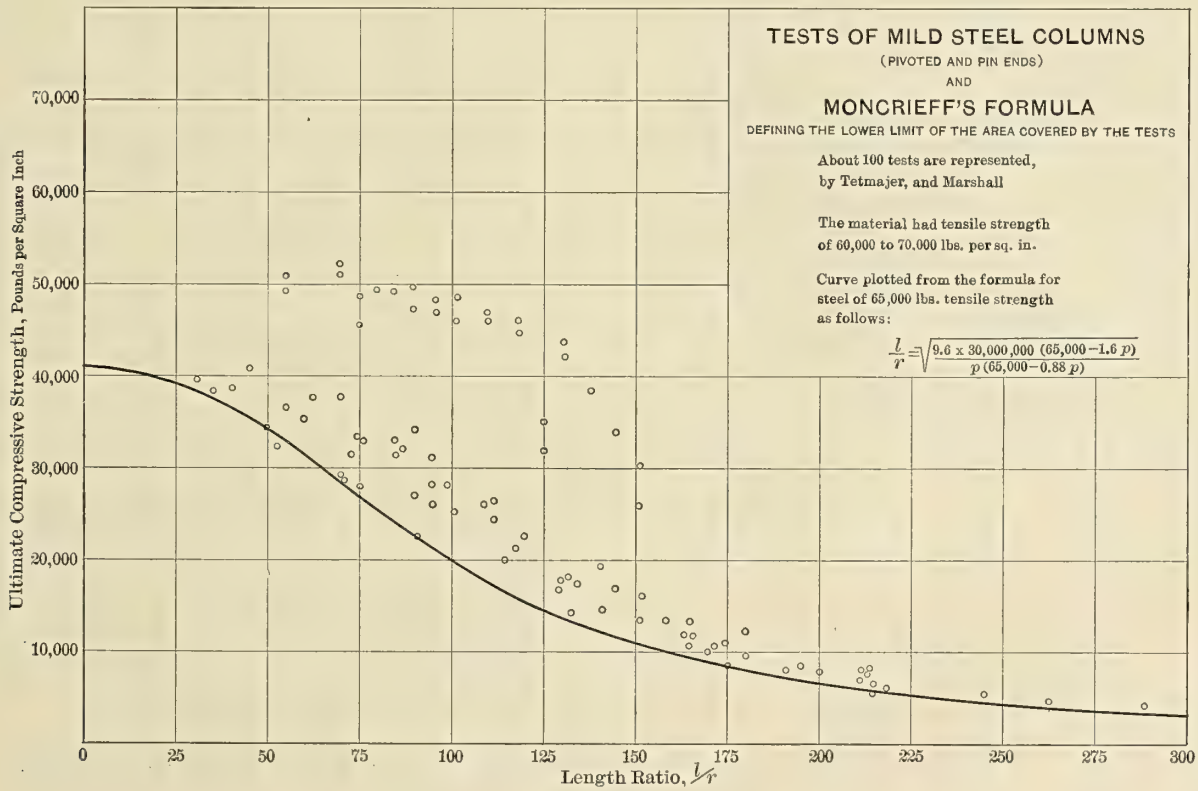


FIG. 3.

Euler's formula establishes the relation existing when the column is at the limit of elastic stability. The column will fail by crushing or by instability according to whether the load producing an ultimate crushing stress is greater or less than that causing instability. If therefore Moncrieff's and Euler's curves intersect, it would be necessary to pass from one to the other at the point of intersection, choosing the lower in each case. However, when the value 0.6 is used for the eccentricity, Moncrieff's curve is entirely below Euler's, rendering such a transition unnecessary. This point will be touched on again when dealing with factors of safety.

The value of f used by Moncrieff is the ultimate strength of the material. Prof. Johnson uses f equal to the elastic limit. A number of other authorities assign the elastic limit as the real ultimate strength. Mr. C. C. Schneider in the Quebec Bridge Report states that the real ultimate strength is the yield point or commercial elastic limit as given by the drop of the bar. There seems to be some confusion among those who hold to the elastic limit as to whether it is the load producing a stress in the extreme fiber equal to the elastic limit, or the load producing an average stress over the entire section equal to the elastic limit. None of the formulas is strictly applicable when the stress in any fiber exceeds the elastic limit. The same is true, however, of the ordinary formula for cross bending, in which case it is generally considered orthodox to use the ultimate strength of the material for the stress in the extreme fiber at failure. Tests made on very short compression specimens (l/r about 5, Tetmajer and also Marshall) show an *average* stress at failure about equal to the elastic limit. By using the ultimate strength of the material for the stress on the extreme fiber at failure, Moncrieff's formula gives an average stress at $l/r = o$, about equal to the elastic limit. Moreover, with this value for the extreme fiber stress, Moncrieff's formula fits the tests. It seems proper, therefore, to use this value.

WORKING STRESSES.

Having decided upon the most suitable formula for the ultimate strength of the column, it remains to determine the proper method of arriving at safe unit loads. Two methods present themselves: Either the value of f in Moncrieff's formula can be taken as the safe fiber stress instead of the ultimate fiber stress, and the formula thus modified be used for determining the safe average unit loads directly, or the safe loads can be obtained from the ultimate loads by applying a factor of safety, which may be either constant or variable.

The former method is that followed by Moncrieff. It gives unsatisfactory results for a reason apparently not fully appreciated by Moncrief. Eidlitz shows (Proc. Am. Soc. C. E. 1896) that the ratio between the average load and the stress on the extreme fiber cannot be constant, a fact also evident from Moncrieff's formula. The reasoning is as follows:

Let p = the unit ultimate average load and
f_c = crushing strength of the material;

then, if the direct load is deducted from the maximum there remains for the bending stress $f_c - p$.

Now if θ be the deflection, m the section modulus and a the area,

then $$\frac{1}{m}\,\theta\, p\, a = f_c - p$$

$$f_c = p\left(1 + \frac{1}{m}\,\theta\, a\right)$$

Similarly for some other stress f, less than f_c, we have $p_1 < p$ and $\theta_1 < \theta$,

and $$f = p_1\left(1 + \frac{1}{m}\,\theta_1\, a\right)$$

Now f/f_c can vary as p_1/p only when $\theta = \theta_1$; hence the condition is impossible; that is, *the stress in the extreme fiber does not vary in direct proportion to the direct load,* from which Eidlitz concludes that the safe average unit load should be proportioned to the fiber stress. By carrying the reasoning a little farther, however, a quite different conclusion is arrived at.

Putting $n\,f = f_c$ and $k\,p_1 = p$, where n and k are constants, we have for the ratios of loads and stresses:

$$\frac{f}{nf} = \frac{p_1\left(1 + \frac{1}{m}\,\theta_1 a\right)}{k\,P_1\left(1 + \frac{1}{m}\,\theta\, a\right)}$$

from which it is evident that with $\theta_1 < \theta$, k must be less than n, or, in other words, a factor of safety of, say, 3, with reference to the extreme fiber stress, will provide a factor of safety of less than 3, with reference to the total load.

As an illustration of his method of arriving at a working formula, Moncrieff takes the case of mild steel, taking $E =$ 30,000,000, and $f =$ 24,000 pounds per square inch as a safe stress in the extreme fiber. He plots this curve, and also Euler's curve, the latter with a safety factor of 3, and finds that the two curves intersect at $l/r = 88$. Now in comparison with his curve for ultimate strength, his working stress curve has, at $l/r = 1$, an average safe load equal to ⅜ of the ultimate, or a true factor of safety of 2 2/3, while, at $l/r = 88$, his working stress curve has an average safe load equal to 3/5 of the ultimate, or a true factor of safety of only 1 2/3. Concerning this, Moncrieff says: "The writer thinks that, like himself, other engineers would hesitate to adopt heavier loads, in relation to ultimate strength for a column 89 or 90 radii long, than would be considered safe for columns only one-quarter of the length." He therefore applies to E in his formula a factor which has the effect of decreasing the average load, as l/r increases relatively to the average load given by the unaltered formula. His formula thus modified gives a more logical factor of safety, but has lost its rationality and has become empirical. The method of arriving at a safe average load by reference to a safe extreme fiber stress is thus evidently incorrect.

The second method cited, namely, that of applying a factor of safety to the average load, as given by the formula for ultimate strength, is, therefore, the method to be used. The question is as to how this factor of safety should be determined. Prof. Johnson, in arriving at a working formula, so arranges his formula that the factor of safety will decrease as l/r increases. He bases this upon the fact that the effect of the eccentricity decreases as l/r increases, and as the eccentricity is contained in his working formula only in the shape of a factor of safety, this is undoubtedly a reasonable provision. The Pencoyd tables, on the other hand, provide for an increasing factor of safety with increasing l/r, "owing to the greater inability of the long struts to resist cross strains, etc." In the case of Moncrieff's formula, as the effect of the eccentricity has been discounted by using the curve defining the lower limit of failure, i. e., the upper limit of eccentricity, the reasoning leading to Prof. Johnson's decreasing factor of safety does not apply, nor does there seem to be sufficient force in the Pencoyd assertion to warrant an increasing factor, except, possibly, in special cases. The factor of safety was therefore kept constant for varying values of l/r.

Now it is becoming pretty generally recognized that, although the nominal factor of safety of a tension member may, for convenience, be based upon the ultimate strength of the material, the true factor of safety is the ratio of the working stress to the elastic limit. The elastic limits in compression and in tension being practically equal (except in the cases of

cast iron and timber), and it having been pretty well proven experimentally, as noted above, that columns having a length ratio of 5 (i. e., practically 0) fail at an average load equal to the elastic limit, if a factor of safety be applied to the curve of ultimate strength such that the average load at $l/r = 0$ will become the same as the allowable tensile stress, the true factors of safety for tension and for compression members will be practically equal. In other words, if it be determined for any structure composed in part of tension members and in part of compression that a certain safe stress, say 15,000 pounds per square inch, should be allowed for the tension members, then the compression members should be proportioned from a curve which gives a value of 15,000 pounds for the average unit load at $l/r = 0$, and the structure, when so proportioned, will have equal strength throughout.

In the preparation of the Construction and Repair column tables, the method followed was first to set up the curve of ultimate column strength for the given material from the formula; second, to divide the ultimate tensile strength of the material (f_t) by the nominal factor of safety; third, to find the ratio of this quotient to the ultimate column strength at $l/r = 0$, which gave the "true factor of safety," and, finally, to apply this true factor of safety to the values read from the curve, the results being the safe average unit loads corresponding to that nominal factor of safety. Inspection of our formula shows that the ratio of the true factor of safety to the nominal factor, when derived in this manner, is as 1 is to 1.6; for convenience, the true factor may be taken as six-tenths of the nominal factor. This ratio is, as stated, practically the same as the ratio of the elastic limit to the ultimate tensile strength, for most engineering materials.

It should be added that the value of the ratio $\frac{\text{ultimate unit load}}{\text{safe unit load}}$ is properly less when the ultimate load is based on Moncrieff's formula than when it is based on a formula intended to average the results of experiments, the difference between Moncrieff's formula and others being due to the definitely allowed-for eccentricity, which in the case of the averaging formulas has to be covered by an additional factor of safety, which is in this case truly a factor of ignorance.

FIXED, FLAT AND PIN ENDS.

So far consideration has been given only to the theoretically round-ended column, which is incapable of taking any bending moment at the ends, although it should be noted that the assumption of a parabola made by Moncrieff for the elastic curve carries with it the existence of a small moment at the ends.

If a column be rigidly fixed at the ends, the strength of the column will be the same as that of a column of equal section and half the length. If a column have flat ends, bearing upon surfaces rigidly held parallel, it will have the same strength as a fixed end column of equal length and section, unless the conditions of bending are such as to develop tension on the extrados. (Moncrieff's formula can be arranged to express this condition.) If a column receive its load through pins at the ends, some friction will occur in the pins, which will impose some bending moment at the ends of the column and so make it stronger than one incapable of taking any bending moment at the ends. Moreover, if the pins be held rigidly by the adjoining structure, the column is fixed ended in one plane, while pin ended in the other.

The asumptions with regard to fixed and flat ended columns are, however, never realized in practice. The degree of fixity of the end will depend on the rigidity of the part to which it is fixed and on the deflections to which this part may be subject. Any deflection in a member to which a column is fixed sets up secondary stresses in the column. There exist methods for calculating these secondary stresses, and in large and important work they can be taken into account and quantitatively allowed for. In the case of the class of work for which the shipwork tables will be principally used there is no likelihood that secondary stresses will be calculated and the probability is that their presence will generally be unthought of.

Moncrieff states, after discussing the difficulties as to fixing the ends of columns, "the estimation of this degree of fixity demands the most careful consideration on the part of the engineer." Mr. C. C. Schneider (Quebec Bridge Report) says: "For compression members, with hinged ends, the friction of the hinges should be entirely neglected, and even for compression members with riveted, and, therefore, partly fixed ends, the free buckling length should not be assumed less than the distance between connections on account of the secondary strains due to the elastic deformation of the truss. These secondary strains may . . . . partly or entirely counteract the fixity of the ends."

It appeared, therefore, that for the purposes of the Construction and Repair tables, and having in view the class of work upon which they will be used, no distinction should be made between the different types of ends, and a single set of tables, based upon the round-end column, should be used regardless of any fixity of the ends. It seemed proper, however, in the case of a pin-ended column to use the radius of gyration corresponding to the probable direction of flexure, that is, the radius of gyration which lies in a plane normal to the plane of the pin. However, as the most favorable effect of fixity of ends possible would be to halve the column length, and hence to halve the value of l/r, it is permissible in such cases to use the greater radius of gyration only when it does not exceed twice the least radius of gyration.

The tests so far made at the Watertown Arsenal, in accordance with the programme laid down by the American Society for Testing Materials, show no advantage for fixed or flat ends over round and pin ends ("Engineering News," Aug. 26, 1909, and Proceedings American Society for Testing Materials, volume 8, page 336). This may have been due to lack of straightness in the specimens and to other causes, and is not borne out by the experiments of others, but the conclusion that "centrally applied or axial loads may be sustained with equal success without regard to the type of end bearing" may, nevertheless, be considered as a practical one.

(To be concluded.)

METALLIC LIFE-BOATS.

In the construction and maintenance of ships there is probably no problem which causes more vexation and annoyance than the question of properly equipping the vessels with life-boats, as prescribed by law. As a rule, the naval constructors and architects do not waste much time on the life-boat question, but simply enter in their specifications: "Life-boats to be in accordance with the law," and in the United States that means—in accordance with the rules of the Steamboat Inspectors. This leaves it entirely in the hands of the shipyard to comply with said rules, and, naturally, the cheapest equipment which can be considered as complying with the law is chosen; the representative of the shipowners should, of course, see that this equipment is of the most modern type, but unless the specifications call for certain stipulated requirements over and beyond what the law actually requires it is a very difficult matter to induce a shipbuilder to furnish other than the very cheapest boats.

With regard to boats there is a very wide scale of a difference between the cheapest and the best, and even a wider difference of opinion. In the United States metallic life boats

AMERICA
First to apply Vanadium Cast Steel to Locomotive Frames. 1,000 now in service.

GERMANY
The leading country in metallurgical research has adopted Vanadium Steel.

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Exports Vanadium Tool Steel to America and sells it here because of its fine qualities.

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Makes superior automobile parts from Vanadium Steels.

VANADIUM STEEL IS EFFICIENCY STEEL

Vanadium increases the tensile strength and elastic limit of all steels, and gives a very high elastic ratio. It makes strong steel that isn't brittle. It makes elastic steel that is strong. It is used in forgings, plates, wire and castings. It must be added to melted steel. Small proportions are very effective; not less than one-tenth of one percent, and rarely more than eight-tenths of one percent is the full range. Vanadium is first alloyed with iron, to secure a low melting point. This alloy is called Ferro-Vanadium.

Early experiments with Ferro-Vanadium often failed because the alloy wasn't properly made,—contained too much carbon. We have our own mines, refine the ore at our own factory, and guarantee our Ferro-Vanadium to be the best quality for use in iron or steel. Our years of experience in the development of this alloy will save you trouble and expense. Write for literature and information.

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Our experience is available if the question of the *Right Steel* interests you.

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VICTOR VANADIUM
BRONZE CASTINGS

This Bronze composition is particularly adapted for Modern Marine Service, and is rendered tough, strong and uniform by the incorporation of Vanadium, which is considered the greatest of all scavenger alloys, imparting to the metal greater wearing qualities. This bronze is ten per cent lighter in actual weight than any other bronze casting of the same pattern.

These castings can be forged.

The structure is close and clean, capable of withstanding high pressure for valve service.

A cylinder 9-16 of an inch thick, three inches in diameter and fifteen inches long has been subjected to a pressure of nine thousand pounds.

TENSILE STRENGTH on 1" Section:
56000 to 65000 lbs. per square inch.

ELASTIC LIMIT:
22000 to 34000 lbs. per square inch.

This metal is used in submarine vessels in Japan, Austria, Russia and every vessel of this type in the United States.

VICTOR VANADIUM
NON-CORROSIVE SILVER METAL

This Metal is non-corrosive and is particularly useful for sea-going service.

It finishes to a silver color and takes a high polish whose lustre can be maintained quite readily by simply rubbing, adding greatly to its usefulness and effect as ornamental hardware for marine use

It is an ideal metal for propellers, for it withstands salt water and all vegetable and mineral acids, nitric acid excepted. It is of great strength and toughness and should be used for valves and couplings for fire apparatus on account of its non-corrosive qualities, in place of nickeled castings, as nickel finally peels off, and this metal not being plated, cannot peel.

TENSILE STRENGTH:
66000 lbs. per square inch.

ELASTIC LIMIT:
36000 lbs. per square inch.

This metal will be found indispensable to marine service when once used.

WRITE FOR CATALOG

VANADIUM METALS COMPANY
FRICK BUILDING
PITTSBURGH, PENNA.

have for years been considered the most desirable; there are, however, still some exceptional cases where owners' representatives insist on having wooden boats. In European ships wooden boats are mostly used, and there seems to be a certain sense of security for the layman in the fact that the boat is of wood, since wood will always float, while iron or steel will sink.

It is certain that wooden boats require constant attention, especially on ships which cruise in many latitudes and are subjected to varying atmospheric conditions, for even well-seasoned material will check and shrink under such conditions. From exposure to heat or cold all wood will expand or contract, and therefore wooden boats have to be constantly looked

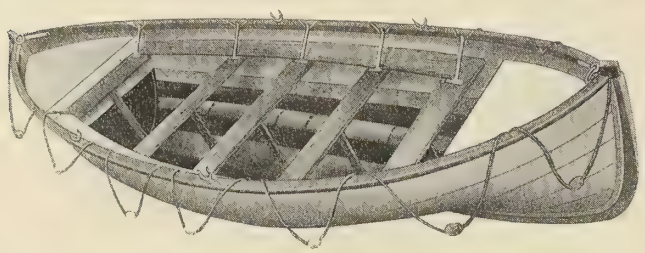

FIG. 1.—TYPE OF METALLIC LIFEBOAT USED IN THE UNITED STATES.

after, calked and painted, etc., in order to be in seaworthy condition should occasion arise to use them.

This trouble is almost entirely eliminated in metallic boats. Whereas steel will also expand and contract somewhat, accordingly as exposed to heat or cold, still this action is so slight that it does not affect the tightness of the boat's seams at all. Besides, they do not need as many coats of paint and the calking need not be renewed periodically. Another advantage of metallic boats is that they are, as a rule, much lighter than wooden boats.

In Europe the metallic boats used are made of pressed steel; the two halves of the boat being shaped and joined at stem, stern and keel. These boats enjoyed a certain degree of popularity for a time; but corrosion soon set in, particularly where the wooden gunwale and molding was attached. The concerns who installed such boats, therefore, found it necessary to remove the gunwales, etc., about once a year in order to repaint the metal and so protect it against rusting, but this procedure made the up-keep of pressed-steel boats rather expensive. Moreover, these metallic boats are considerably heavier than the ordinary wooden boat, whether built lapstreak or smooth, and this may account for the predominance of wooden boats on European ships.

The metallic boat referred to, which is lighter than one of wooden construction, is the type of metallic boat built in the United States. Here galvanized sheet metal is attached in longitudinal strakes (with flannel between the seams) to oak keel, stem and sternpost; the seams are riveted with countersunk rivets, thereby insuring a smooth surface. Owing to the additional stiffness given by the lapped seams, where the metal is double, it was found possible to use a comparatively light gage of metal, and therefore boats so constructed have only about half the weight of the ordinary wooden life-boat, and yet they are very strong and durable. One of the greatest advantages of such a metallic life-boat is the little up-keep required. As all the metal is galvanized—not only on the outer and inner surface but in the seams and wherever wood is attached—it withstands corrosion for a long time.

Boat builders, who are often called upon to repair old lifeboats of both wood and steel, have a splendid opportunity to secure considerable data as to the comparative strength and durability of wooden and steel boats, and from them we learn that, although more steel boats than wooden ones are in use in the United States, it is a fact that they are more often required to repair wooden boats than metallic. During the hurricane season, when ships often come to port with their boats more or less damaged, it is invariably found that a wooden boat has been smashed beyond repair, whereas a metallic boat may have only a few small dents which are readily repaired without much expense or loss of time. Figs. 2 and 3 show a couple of boats which were on board a ship which ran ashore last year. The boats were used for transferring passengers to another ship, and during the transfer were pretty badly smashed, as the large dents will show; nevertheless, and in spite of the tremendous bulges, the boats were perfectly serviceable and tight and served their purpose admirably at the time. To anyone familiar with boats it will at once be apparent, on seeing the dents and bulges, that a wooden boat under the same conditions would have been splintered to kindling.

Regarding the durability of the type of metallic boat used in the United States, it has been found, when undertaking repair jobs on boats which had been in use for twenty years or more, that when the molding was lifted off at the gunwale, the galvanizing and the metal were perfectly intact. In spite of this there are still a good many who fear that corrosion and rust may have made the boats unfit for use when they are

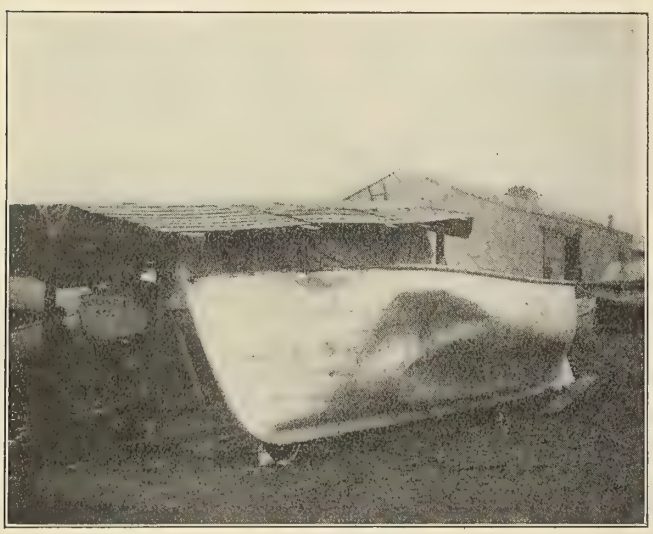

FIG. 2.

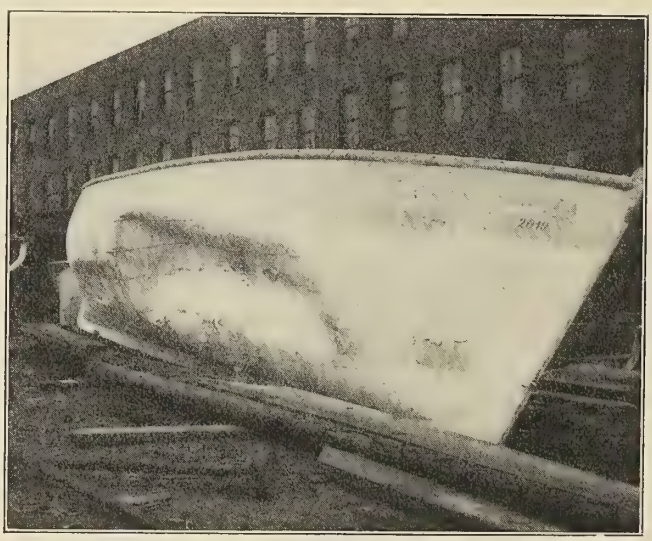

FIG. 3.

most needed, and this prejudiced element prefers to pay practically twice as much for a wooden life-boat. During the last year or so, therefore, attempts have been made to build life-boats of non-corroding material, and it has been found that life-boats built of sheet bronze, reinforced with oak ribs and stringers closely spaced, afford a satisfactory construction which combines the advantage of the metallic boat as above set forth with the more or less imaginary advantages of the wooden boat, viz.: no rot or leakage, etc.

These bronze boats are built in the same way as the ordinary metallic boat as regards the riveting, lapping of seams, etc., with the exception that the wooden ribs are inserted after the boat has been shaped on the mold and riveted up. These ribs are steam-bent and attached to the metal shell by means

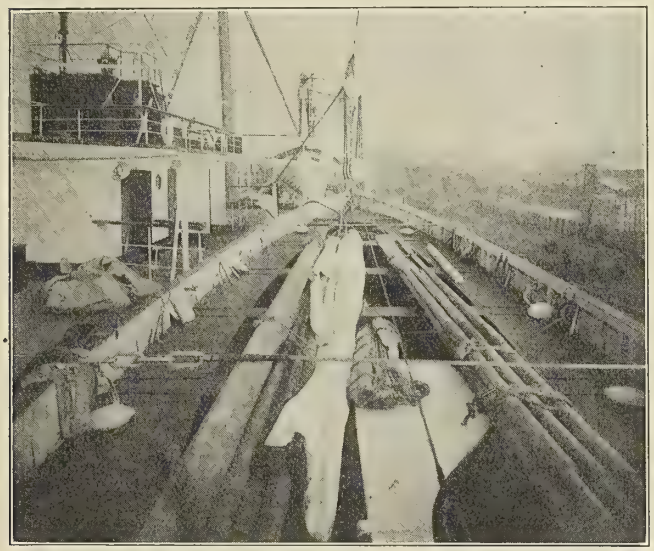

FIG. 4.

of U-shaped clips passing over the ribs and riveted to the plating, so that all riveting is metal to metal and all danger of leakage is obviated. The cost of a bronze boat is about 10 to 15 percent more than that of a first-class wooden boat, but the lasting qualities of bronze boats apparently more than compensate for the slightly increased cost, and, moreover, such boats require practically no up-keep.

In the up-keep and preservation of life-boats, it is generally not only the structural details that have to be taken into consideration, but also the way they are placed and chocked on deck, and secured by gripes and covers, etc.

As regards the chocking and griping of the boats, it is not always so very easily done nowadays when we first consider that as much deck space as possible should be saved and also that attention is more and more drawn to the readiness of having them quickly launched. Of course, as far as launching is concerned, the davit arrangement forms the principal part, but outside of this a great deal of time can be saved by improving the releasing of the gripes and the chocks. In the old-fashioned way of griping boats Pelican hooks are generally used which are often clogged up with rust or paint, and unless the lanyards are of rope and can be quickly cut away it naturally takes quite some time to release the same. Besides the gripes being extended with clamps from the gunwale on each side to the deck, it is necessary for one man to go outside the boat to release the gripe on that side, and in stormy weather this procedure may be somewhat risky; also in a very high sea, when shipping great quantities of water, it sometimes happens that the covers are smashed in and the boat is filled with water, and the tension of the gripes from the gunwale on each side often helps in damaging the boat, and in some cases splits it open fore and aft.

For this reason the continuous gripe arrangement shown in Figs. 4 and 5 has been developed. This continuous gripe arrangement has two decided advantages. One is that it is automatically released at the same time the chocks are being released, and the other is that if the vessel should ship great quantities of water in a very heavy sea, it would tend to hold the boat together instead of splitting it apart, and, above all, it would also hold the boat down to the deck in any condition that may arise.

There are a good many questions regarding life-boats, and particularly regarding those built in the United States, which might be considered, but, as stated before, there are about as many different opinions on this subject as there are authorities, and probably for this reason most people are satisfied so long as the life-boats conform to the rules laid down by the U. S. Steamboat Inspection Service. Conformity to these rules would seem to indicate uniformity of construction, but such is not the case. The various inspection districts interpret the rules in different ways; for instance, some insist on having the tanks built into the boat and others want independent tanks; still others want all the lower woodwork, such as keel, stem and sternpost covered with sheet metal, and some

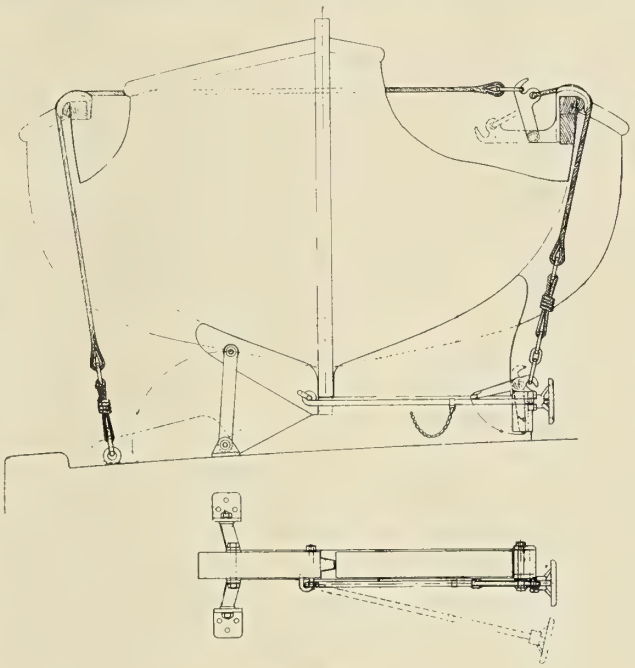

FIG. 5.

want it bare. Although the laws laid down by the Government for the Steamboat Inspection Service are supposed to be the same as those by which the various inspectors are guided, yet there seems to be a wide margin for the personal opinion of the individual, and, owing to the different construction put upon such laws by the various inspectors, owners and captains of steamboats experience considerable annoyance and expense when their ships are inspected in different districts, for although their boats may be in compliance with the requirements of the one, certain changes may be necessary to satisfy the other.

The Bureau of Navigation reports 82 sail and steam vessels of 14,375 gross tons were built in the United States and officially numbered during the month of October, 1910. Six steel steamers of 11,686 gross tons were built on the Atlantic Coast.

EIGHTEENTH ANNUAL MEETING OF THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

The eighteenth annual meeting of the Society of Naval Architects and Marine Engineers was held in the Engineering Societies building, New York, November 17 and 18, 1910. According to the report of the secretary-treasurer fifty-five new members were elected during the year and thirty-nine were elected at the present meeting. The total receipts for the year were $10,715.67 (£2,680), and the total disbursements, $10,797.65 (£2,700).

PAPERS READ NOVEMBER 17.

No. 1—Notes on the Armaments of Battleships.

BY SIR WILLIAM H. WHITE, K. C. B.

(This paper is published in full on page 497.)

No. 2—Evolution of Screw Propulsion in the United States.

BY CHARLES H. CRAMP.

PART II.

ABSTRACT.

The period of the greatest activity in shipbuilding in this country, as far as the hulls were concerned, which were all of wood, was between 1849 and 1860, and it was about that time that iron had begun to take the place of wood in Great Britain. It was at the close of the demand for a high class of vessels, which originated during the famine in Ireland, that gold was discovered in California. This necessitated quick transportation for trade and travel, and the great American clipper, which had been introduced in the East India trade, had developed into the highest state of perfection ever attained in the art. The investment due to the favorable conditions of the time was a correspondingly profitable one. This might also be said of certain paddle-wheel steamers that began to make their appearance about the same period.

Both of these classes of ships, particularly as far as the hulls are concerned, were by all means the greatest and most interesting specimens of naval architecture that the world has ever witnessed; not only as traders, but for the beauty and gracefulness of their design, completeness of their equipment and seaworthiness.

The great character and high standing of these ships, with all relating to them, began in 1853 to lose that important position they had acquired before that time. The building of the *New Ironsides, Monitor* and *Galena* was an event that led to the effectual and final destruction in this country of the great shipbuilder whose career and occupation had been so distinguished in connection with the great packet and clipper, and had covered him with so much glory.

Having been convinced at an early date that we should take up iron shipbuilding, we commenced in it by building the side-wheel tow-boat *Lehigh* to take the place of the old boat of the same name. Previous to 1847 all towing was done by the paddle-wheel boat, mostly by old ferry-boats; these were to be found everywhere in the United States and Cuba, but at an early date we built the screw tug *Sampson*, which was the first screw tug-boat built in this country. Later on we built the *George W. Clyde*, the first ship built in this country with fore-and-aft compound engines.

The success of the experiment on the *George W. Clyde* was greater than we expected, and we concluded to build compound engines and not consider any other type in our business as builders of complete steamships.

The building of the *Pennsylvania, Ohio, Illinois* and *Indiana*, between 1873 and 1874, was an event of much importance, particularly as the ships were propelled by screws and the engines were of the John Elder type of compound engines. The ships were subjects of much consideration on their arrival in Liverpool, many of the principal shops sending their draughtsmen to look up the flanging in the boiler heads and fire-boxes of the boilers; no flanging of these or any other part of a boiler had been done before in Great Britain. They also took some trouble to examine the white metal in the bearings of these ships.

No. 3—The History and Economic Value of Canals, with Special Reference to the Cape Cod Canal.

BY COMMODORE J. W. MILLER.

ABSTRACT.

From a casual study of the history of canals two facts present themselves:

1. That a congested and interior population naturally seeks the sea for wider markets.

2. That wherever practicable traffic will ultimately reach the sea by water, which has been, and again will be, the cheapest of all routes.

The truth of these axioms is to be seen from remotest time.

From an engineering point of view, the problem of constructing the Cape Cod Canal is not great. The total length over the isthmus is 8 miles. The total length to 30-feet depth in both bays is 13 miles. The soil to be cut is sand, and amounts to 17,000,000 cubic yards. The deepest cut is 29 feet above tide-water. The channel at both ends of the route, the natural marshes and streams already furnish a waterway for boats of light draft. The difference in tide between the two bays necessitates no locks. The depth of the canal is to be 25 feet. Minimum width of bottom 100 feet through the central portion of the canal; this will give a surface width at the narrowest point of 250 feet. The approaches will have a minimum bottom width of 250 feet. The right of way has been obtained, and in addition other tracts of land essential to the undertaking.

Agreements for the change of the railroad line have been made with the N. Y., N. H. & H. R. R. Co.; the railroad bridge necessitated thereby is completed; four dredges are deepening the 5-mile western approach from Buzzards Bay; two large suction dredges are removing about 20,000 cubic yards per day for the channel through the marshes at the eastern end of the canal.

A breakwater, 3,000 feet in length, is being built to the northward of the channel, where it enters Barnstable Bay. Several other dredges are at work on the central portion of the line. Administration and other buildings have been bought and the necessary preparation made for a campaign of activity on the ground during the coming winter.

The bridges are being constructed on the basis of an ultimate depth of canal of 34 feet. They will each have an opening of 160-feet span of the type known as the Bascule lift bridge. The local travel across the canal will be accommodated by such bridges or ferries as experience may dictate.

The final estimates for the canal include the thorough electric lighting and other aids to navigation of the whole channel and approaches requisite for a region where fog prevails.

The tonnage through Vineyard Haven Sound to-day, which will be all tributary to the canal, amounts to 25,000,000, of which there is:

Coal	9,000,000 tons
Stone	300,000 tons
Nova Scotia plaster	250,000 tons
Oil	200,000 tons
High-class merchandise	2,000,000 tons

the remainder being crude material of various descriptions.

The number of passengers between New York, southern and eastern points, by water is to-day over 500,000. This amount

will be greatly increased through the opening of the canal, as the neighboring regions will be much more accessible, and steamers of the Sound type can leave New York late in the evening, land their passengers at desirable resorts, and arrive at Boston early the next morning.

The N. Y., N. H. & H. R. R. Co. runs along the southern bank of the canal. A large manufacturing center will be developed at the eastern end, where mills will have the advantage of both land and sea transportation. Water abounds in the hills back of the center of the line, and on these hills an increasing summer population will undoubtedly be settled.

Skepticism as to the success of the canal has been natural, being based on the conditions of the past, when the great majority of the coastwise tonnage was carried in sailing vessels.

To-day—

(*a*) This tonnage is under the control of a small number of corporations, which tow the merchandise in barges containing from 1,000 to 3,500 tons.

(*b*) The towing companies now require a plant for a three-weeks' round trip on account of the dangers and delays via Vineyard Haven route.

(*c*) The cost of this plant will be reduced at least one-third, for the reason that not only is the distance shortened sixty-six miles, but the duration of the trip is greatly diminished.

(*d*) Insurance from perils of the sea will be lessened.

(*e*) The congested railroad systems of the Atlantic Coast are now heartily in favor of water transportation for crude material, thus relieving their lines for the transportation of high-class merchandise and passengers.

(*f*) This new waterway is not in the strictest sense a canal, but a short passage connecting two portions of a much-traveled route through which a known traffic exists. Its conditions are analogous to those at Suez, where the profits have far exceeded the estimates.

(*g*) Humanity demands the elimination of the dangerous, stormy and fog-bound route around the Cape. The loss of life and property in that locality has been appalling. The record, more or less incomplete, from 1843 to 1903, gives a minimum of 2,131 vessels wrecked in the Nantucket Shoals region, 908 of which were a total loss. Ten complete crews disappeared with their ships, and in addition, about 700 men lost their lives.

The completion of the canal will render unnecessary the proposed dredging of Pollock Rip channel at an estimated cost of some three million dollars, a sum which could be much more advantageously used by the Government in the neighborhood of the canal rather than being wasted in the tortuous and ever-shifting channels off Chatham.

No 4—Coaling Warships—Notes of Progress.

BY SPENCER MILLER.

ABSTRACT.

One of the United States colliers (purchased during the Spanish-American war) discharged with its own gear from its four hatches 1,200 tons of coal in ten hours, 120 tons per hour, or 30 tons per hour per hatch. About 100 men were required to fill the coal bags in the hold. For a single hour 50 tons of coal per hatch may be discharged.

In contrast to this the United States navy collier *Hector* discharged 190 tons of coal from one hatch in one hour, employing a self-filling bucket operated by two men. This means a great saving in manual labor as well as a saving of time. In time of war the importance of reducing the labor of coaling is apparent to everybody.

The United States Navy Department began a few years ago to build colliers from their own designs or prescribed characteristics. The first two were the fleet colliers *Vestal* and *Prometheus,* both 16-knot ships, carrying 6,400 tons of coal each. Next were the *Mars, Vulcan* and *Hector,* sister ships, with 12 knots speed and 7,200 tons carrying capacity. The colliers *Cyclops* and *Neptune,* now under construction, will have 14 knots speed and carry 12,500 tons of coal each. All of these colliers, excepting the *Cyclops,* carry a novel form of coal-discharging gear known as the Marine Transfer. The *Cyclops* will discharge its coal by self-filling buckets, but with a different system of rope leads not at present known by the author.

The Marine Transfer on the colliers *Mars, Vulcan* and *Hector* comprises the winches and a novel form of rope lead with blocks and ropes to operate a self-filling bucket for discharging coal from a collier. The masts and booms on these three colliers are cheaper than on the *Vestal* and *Prometheus,* but they are less favorable to the operation of the Marine Transfer. A far greater amount of coal can be taken out of these colliers with the clamshell bucket before trimming is necessary than is possible on the *Vestal.* The operation of the bucket is practically the same on all the colliers.

In the official coaling trials discharging into a barge and using the large bucket:

The *Mars* handled 137 bucket-loads, aggregating 117 tons.

The *Vulcan* handled 155 bucket-loads, aggregating 180 tons.

The *Hector* handled 175 bucket-loads, aggregating 190 tons.

Ordinary seamen on board these colliers were drilled to operate the Marine Transfers with the clamshell buckets, from which it has been established that two fairly intelligent men require about eight hours to become sufficiently proficient to be capable of discharging 100 tons of coal per hour per hatch. One hundred and ninety tons of coal per hour per hatch can be discharged at any time with winchmen of sufficient skill and practice.

The author believes that the maximum efficiency in coaling will be attained by employing clamshell buckets delivering coal in bulk directly into bunkers when possible and when impossible into hoppers on the deck of the ship to be coaled, such hoppers to be arranged so that trucks holding about 1 ton of coal can be pushed beneath the hopper and filled therefrom by the movement of a valve or gate, the coal then to be trucked to various parts of the deck, where it can be dumped through coal chutes to the bunkers. Such a method will reduce the number of men involved to a minimum. It would save the cost of coal bags or baskets. It will save the fatigue of the sailors in shoveling coal and carrying baskets or the dragging of bags of coal on the deck. The author believes that coaling with bags will gradually give way to coaling in bulk, and a great saving in the cost of bags will then accrue to the navy.

There are three important points involved in the design and construction of the Marine Transfer winches:

1. The employment of flat metallic slipping frictions with air-cooling passages.

2. The employment of a lever control, which makes the operation comparatively easy.

3. The position of the operator is such that he can see the bucket in all parts of the hold as well as in every position it might take above the hatch.

The metallic slip frictions on all of these colliers involve the use of an extra hard steel plate attached to the gear and the employment of friction blocks made of a special composition. Wire seems to be the only material of which to make the ropes properly.

No. 5—Floating Dry Docks in the United States; Relative Value of Wood and Steel for Their Construction.

BY WILLIAM T. DONNELLY.

ABSTRACT.

The building of timber floating drydocks in the United

States is very old, and there are now in use in the port of New York sixty-four floating drydocks, all of wood, ranging in tonnage from 400 to 12,000 tons, and in the United States there are ninety-one floating drydocks, three of steel and one with steel wings, ranging in tonnage from 200 tons to 18,000 tons, having a total tonnage of 228,800 tons and an average tonnage of 2,500 tons.

The only steel commercial floating drydock is at the works of the Great Lakes Shipbuilding Company, Detroit, Mich. The only other steel floating drydocks in use in the United States are the Algiers dock opposite New Orleans, La., and the steel dock taken by the United States government from Havana during the Spanish war, now in Pensacola, Fla. The Detroit dock and the Algiers dock are in fresh water, which makes their preservation much easier.

All the writer's experience with floating drydocks and their construction and repair leads to the firm conclusion that for underwater work, such as pontoons for the Rennie type of dock, wood is a much superior material of construction to steel, that the original cost is much less, the cost of maintenance less, and the life of the structure greater than steel. For the wings and upper work, experience is equally conclusive for the use of steel. While it is apparent that the cost of maintenance will be considerable, the structure will last much longer, and, with a sectional pontoon dock, where the wings are accessible at any time and any portion of the wings may be entirely replaced if necessary, it would seem that the structure as a whole will last indefinitely.

So far as the writer is able to judge by a somewhat limited experience, the only reliable protection for interior steel work of floating drydocks in salt water is bitumastic compound, but the first cost of this protection is very great, being in the neighborhood of $6 per ton of steel for interior protection only.

A comparison of the materials used for wooden and steel pontoons shows that the weight of the steel per hundred tons of lifting power is 33 tons, and the weight of wood per hundred tons of lifting power is 36 tons. It is evident that the difference in weight must be supplied by increased dimensions of the wooden pontoons. Other than in this particular, wood appears to have the advantage in every way.

While reference has been made to a pontoon dock of 7,000 tons lifting capacity, there does not seem to be any engineering limit to the size to which the Rennie type of dock can be built with wooden pontoons. A carefully worked-out pontoon for a 20,000-ton dock shows dimensions of 130 feet by 44 feet by 15 feet, and it will be readily understood that this structure is well within the practical limits for timber work.

Regarding the cost of the different types of floating drydocks, it is, of course, not possible to make any definite statements, as they are much influenced by the varying cost of material and the location where the dock is to be constructed. For the relative cost of the different types of docks on the eastern coast of the United States, the following figures may be taken as being approximately correct:

COST PER TON OF LIFTING POWER.

	Per Ton.
Balance sectional timber dock with centrifugal pumps	$32.00
All-wood pontoon dock with continuous wings	35.00
Pontooon dock, steel wings and wooden pontoons	42.00
All-steel pontoon dock	57.00
Government steel dock, Dewey type	62.00

The comparative cost for the western coast of the United States will be quite different on account of the increased cost of steel and the much lower cost of timber.

The paper also contains descriptions of various types of floating drydocks with both wood and steel pontoons, and also valuable reference to existing data on the subject.

No. 6—Our Constitutional Shipping Policy and the Compact for its Establishment.

BY WILLIAM W. BATES.

ABSTRACT.

In 1787, a National convention, composed of delegates from all the States except Rhode Island, met, considered and completed the Federal Constitution. The only discussion of the power to "regulate commerce" was in connection with its use for the encouragement of the merchant marine, in which the question was on a resolution that bills for "navigation laws" should receive a "two-thirds vote." This was decided in the negative, and the necessary clause was afterwards agreed to unanimously.

It should be understood that all the powers of the Constitution are derived from the States, and were given up by them and taken over by the Federal Government, not for ornament or to be laid aside, but for actual use—for the advantage and benefit of the Nation forever. The "suspension" of ship protection, or of any other promise, is a violation of compact.

It seems to be supposed by many that Congress may enact laws regardless of the Constitution, and that this charter, given by the States and the people, cuts little figure at Washington. But this is a sad mistake. That we have a constitutional shipping policy extant to-day is no wonder at all. The several States, as we have seen, had a policy of trade regulations, and thought it vital to their commercial independence. They turned this policy over to the United States, the only object being to increase its efficiency, and to get a great Nation to enforce it forever. By this compact the States were relieved of their natural duty to encourage and protect a most important industry, and the United States, by virtue of it, promised and undertook the duty, with no right reserved ever to discontinue it.

Nevertheless, this solemn compact was violated by Congress. At the height of our marine prosperity, in 1826, when our vessels were carrying 95 percent of imports and 89.6 percent of exports in our own commerce, the President recommended the "suspension" of ship protection in the foreign trade.

There was no reason of State for this act. No nation was demanding it. Under its operation for the past forty-five years, with scarcely any protection, our foreign-trade marine has almost disappeared. The different States cannot, as formerly, protect their shipping; and the Federal Government has "suspended" its law for so doing. More than this, Congress has no other way to relieve the situation than to terminate our shipping conventions and to resume vessel encouragement where it was thrown off, beginning in 1828. In other words, the Federal Government has no other course than to resume the observance of the compact and policy of the Union and the Constitution. Moreover, to clinch the argument, the Constitution having provided for a specific method of encouragement and protection (that of trade regulations, meaning "discriminating duties of tonnage and impost"), all other methods are thereby precluded; while there is no authority for the taxation that would be necessary for the fostering of the marine by subsidizing, were that method adopted.

PAPERS READ NOVEMBER 18.

No. 7—An Analysis of Tests of Water-Tight Bulkheads, with Practical Rules and Tables for their Construction.

BY PROF. WILLIAM HOVGAARD.

ABSTRACT.

This paper is a continuation of last year's paper on the "Strength of Water-Tight Bulkheads." While that paper was of a purely theoretical nature, the present paper contains an

analysis of bulkhead tests, followed by practical rules and tables based on this analysis.

The tests here analyzed were carried out on bulkheads of rectangular form stiffened by a system of vertical, equidistant stiffeners of uniform section. This system is used in several navies, it has recently been adopted by Lloyds and Veritas, and has been used for some time by several other classification societies; it is therefore of greater interest and importance than any other system of stiffening. The tests fall in two classes—those where the stiffeners are double, *i. e.*, placed on both sides of the bulkhead, and those where the stiffeners are single, or on one side of the bulkhead only.

The total number of analyzed tests is fourteen, of which six were with double stiffeners, eight with single stiffeners; but several of these tests were made at two or more heads of water. The main results are given in tabular form in the paper, and after analyzing them the author gives a resumé in the form of the following rules, which apply only to ordinary water-tight bulkheads, not to deep tank or to oil-tight bulkheads:

1. A pure system of uniformly spaced vertical stiffeners and horizontal strakes of plating should be used, except where the horizontal extension of the bulkhead is smaller than its height, and where at the same time the brackets of horizontal stiffeners can obtain a rigid attachment, in which case a pure system of horizontal stiffeners should be used. This last condition is fulfilled only in few cases, such as in collision bulkheads. In the majority of bulkheads vertical stiffeners are the most efficient as far as strength under water pressure is concerned.

2. The thickness or weight per square foot of the plating may be determined on the basis of its depth below or its height above the waterline, which corresponds to the deepest draft to which the ship may reasonably be assumed to be immersed in damaged condition. As a general rule it is proposed to make the weight of the strake immediately below this waterline not less than 7 pounds per square foot, and to add 1 pound for each additional 4 feet depth or 1/32 inch for each additional 5 feet depth. For plating above this waterline the weight should be decreased at the same rate. The thicknesses determined by this rule should be considered as minimum thicknesses, and must in many cases be increased to provide for corrosion, for general or local structural strength, or for the forces to which the plating may be exposed by the stowage of cargo.

Below the normal load waterline both butts and seams should be double riveted.

3. The stiffeners should be single, *i. e.*, each individual stiffener should be placed on one side of the bulkhead only. On all stiffeners of any importance a face bar or a reversed bar should be fitted on the free flange so as to balance as nearly as possible the strip of the bulkhead plating, which may be assumed to work with the stiffener.

A more efficient solution could be obtained with bars where one flange is heavier than the other. This would obviate the necessity for face plates or reversed bars, but it is a question whether such bars could be rolled without too great extra cost.

With the thicknesses of plating recommended above, the spacing of the stiffeners should not exceed 4 feet. The stiffeners should all be placed on the same side of the bulkhead.

4. The stiffeners should be provided with efficient brackets both at top and bottom, constructed by splitting the main bar of the stiffeners. The face plate, if any, should be continued the whole length of the bracket, and should have a good end connection. The height and width of the lower bracket should be about three times the depth of the stiffener, but in no case should the height fall below one-tenth of the length of the stiffener. The sides of the upper bracket may be about 10 percent shorter than those of the lower bracket.

The brackets should be attached to a rigid part of the ship's structure, such as a floor plate, a longitudinal or a deck beam, or else reinforcements must be introduced.

5. The bounding angles in all important bulkheads should be double up to a height of about 5 feet below the load waterline.

The author has worked out tables, which are included in the paper, by means of which the thickness of bulkhead plating and the size of stiffener can be determined in accordance with the foregoing rules.

No. 8—Comparative Results in Steam and Coal Consumption with Turbines, Reciprocating Engines and a Combination of the Two on the Steam Yacht Vanadis.

BY CLINTON H. CRANE.

ABSTRACT.

The steam yacht *Vanadis*, of 1,300 tons trial displacement, was built on the Clyde at the yard of Messrs. A. & J. Inglis, from the designs of the writer, and delivered by them in the spring of 1908. The propelling machinery consisted of the usual arrangement of Parsons turbines, with a high-pressure center and two low-pressures driving the wing screws. The guaranteed speed of the vessel was 15½ knots maximum, with a cruising speed of 13 knots, which was to be obtained on a guaranteed consumption of 26 tons of coal per 24 hours. On trial before delivery this guaranteed speed was exceeded by about one knot, and a 12-hour coal test was run at 13 knots when 13½ tons were supposed to have been burned.

At the time the vessel was designed several turbine yachts had been constructed, no one of which had shown economy in coal consumption, so that very special stress was laid on this question of economy at cruising speed. As a consequence the turbines were designed primarily with this end in view. However, the owner reported that the vessel was consuming very much more coal than the guaranteed amount; therefore, at the writer's request an exhaustive series of tests was run in the autumn of 1908, after the turbines, propellers, condensing plant, etc., had been thoroughly overhauled to the approval of the New York representative of the Parsons Marine Turbine Company.

The best test showed a consumption of 33 tons or 27 percent, more than the guarantee. In view of this unfortunate condition is was possible to do one of three things:

1. Lengthen the vessel to increase bunker capacity.

2. Remove turbines altogether and replace by twin reciprocating engines.

3. Remove the center high-pressure turbine and replace by a reciprocating engine, exhausting into the two low-pressure.

No. 3 was decided on. The contract for this alteration was let to the Staten Island Shipbuilding Company, and completed in January, 1910. In May following the vessel was run without propellers on the turbine shafts, being driven by the center propeller only, over the Glen Cove course, and subsequently a four-hour water consumption test was run at the revolutions required for 13 knots. The vessel was then re-drydocked and the turbine propellers fitted to the wing shafts, and in July of the same year the complete standardization coal and water tests were run in the new condition.

The summary of the coal and water consumption results of the three types of machinery is included in the paper. In estimating the amount of water used by the auxiliaries I have used a series of tests made at anchor of these auxiliaries. Apparently in the 13-knot condition with the combination, the propelling machinery is using about 14½ pounds per indicated

horsepower, the reciprocating engine alone about 17 pounds, and the turbines about 20½ pounds.

No. 9—The Gyroscope for Marine Purposes.

BY ELMER A. SPERRY.

ABSTRACT.

The uses of the gyroscope at sea fall properly under four general divisions: First, in affording means for resisting and preventing rolling of vessels or even rolling and controlling their motions at will; second, its use as a marine compass; third, for holding automobile torpedoes to their course; fourth, for artificial horizons in connection with observations at sea. There are two other uses which may be noted, that of recording the motions of ships, and also the use of a small gyroscope in controlling the oscillation of large, active gyroscopes for purposes of preventing rolling motions of the ship in their inception, and thus holding the ship against rolling. The first three only are treated briefly in this paper.

The most extensive use of the gyroscope to-day is probably the automatic steering gear in Whitehead torpedoes. This gear is simply used for the purpose of lateral guiding of the torpedo and holding same to a straight course. It offers positive resistance to any effort to turn it from its course, and this resistance is used to operate valves and, through a secondary motor, the rudders. This use originated with Obrey, an Austrian naval officer.

Our own Leavitt, engineer of the E. W. Bliss Company, of New York, and inventor of the Bliss-Leavitt torpedo, has greatly increased the efficiency of the "gyro" gear of torpedoes, and he has increased its accuracy by unloading the base ring; instead of requiring the base ring to do the work of moving a valve he cuts the duty required down to about one-hundredth of that required in the Obrey gear, and makes it give a simple directive factor to an extremely small pivoted pawl at the instant the pawl is otherwise perfectly idle.

Dr. Schlick has done much in connection with the gyroscope. He has gone further in the installation of large gyroscopes for steadying ships than any other. His gyroscope is of the passive type.

The question is often asked: Why is the gyroscope better than a moving weight in a ship for roll quenching? Barring the matter of list produced by the changes of center of gravity of the ship by the moving weight, the reason is perfectly apparent when you recall the magnitude of the stresses obtainable from a small machine. Every pound in the rotating mass of the gyroscope can easily be made to do the work of from 150 to 200 pounds, and directed in any desired line or plane, whereas, when we use water or any other form of moving weight, each pound represents a pound only, and can do the work of only a pound, and only in a vertical direction.

With the active type of gyroscope we find that a small part of 1 percent of the displacement of the ship will perform a very substantial service, down to the point of practically fully extinguishing the rolling. By the use of this device there is entire absence of any shift of the center of gravity of the vessel, and its stability remains unchanged. The sizes, weights, speeds and location of a gyroscope for this purpose are among the points which have been canvassed in tests carried on at the Washington navy yard during the past winter by Capt. D. W. Taylor.

The practical effect in operation of the active type of gyroscope is to secure a large reduction of weight over and above that possible with the passive type. With the smaller angles of roll, the gyroscope would have to be large enough so that its small angles of response would develop the required energy for extinguishing or still further reducing the roll, complete extinguishment being impossible; whereas with the active type the full 180 degrees oscillation of the gyroscope is always available, where required, for the extinguishment of large or even the smallest angles of roll as necessary. Thus an extremely small machine, taking advantage of the larger angles, between twenty and thirty times as large, is sufficient to accomplish this purpose.

When the motive power of vessels changed from an upsetting force to one almost exclusively of forward thrust, the design of ships underwent quite radical changes in connection with lines affecting the stability, decreasing this factor and favoring decreased resistance, aiding the attainment of higher speeds. Now that stability may be imparted to a structure of naturally small righting movement, and, as is well known, even to structures of unstable equilibrium, it is possible that we are on the eve of even more radical changes in design. Ships may now be designed that are practically free from those ballistic qualities which favor rolling structures to which unequal sea pressures easily impart motion need no longer be employed, as a comparatively small gyroscope which can easily be present in duplicate may very readily hold them practically free from rolling motions in such a way that ordinary seas will have little or no effect upon them, while an exceptional wave will have only a temporary effect. I heartily commend this subject to those who are interested in providing safety and comfort to passengers at sea, and as also preventing deterioration of certain classes of freight; for instance, live stock is known to suffer heavy depreciation in stormy weather. This is entirely outside naval uses especially as related to gunnery, trimming ships to secure level gun platform, suppression of recoil from broadside firing, and other uses.

In the cases where the gyroscope is employed as a battle compass, the apparatus is placed below decks, and small instruments about the size of an ordinary compass are distributed in different positions on the ship, giving the exact indications of the gyroscopic compass itself. My work has extended to the point where action of such instruments can be controlled from the gyroscopic compass and distributed as desired, the indications being accurate to a very small fraction of a single degree. Many observations have been made indicating that they are accurate to thirty-six hundredths of an entire circle. It will be understood that this type of compass is not affected in the slightest degree by the steel of the ship, or cargo, nor any magnetic disturbances in either; neither should shifting cargo, turning turrets nor gunfire disturb its accuracy or reliability, nor is it affected in the slightest by those disturbances technically known as deviation or variation.

No. 10—Some Suggestions for Reducing the Loss of Fire on Vessels.

BY SAMUEL D. MC COMB.

ABSTRACT.

The author of this paper calls attention to the appalling extent of the fire damage to shipping annually, and states that with a little precaution most of this loss could have been avoided. While the ideal construction would be to have a vessel constructed entirely of non-combustible material and carry only non-combustible cargo, nevertheless this is a condition which, of course, is impossible, but which can be closely approximated as far as the vessel itself is concerned. From the standpoint of fire hazard, vessels can be divided into three general classes, namely: Steam, gasoline and those with no power. Each of these three classes is taken up separately in the paper, and the principal causes of fires and the methods of extinguishing them are given in each case. The author has evidently drawn upon a fund of practical knowledge and his suggestions are numerous and valuable. It is impossible within the space of a brief abstract to enumerate the many details mentioned, but the paper will be published in more complete form in a future issue.

No. 11—Two Marine Installations of Producer Gas.

BY CHARLES B. PAGE.

ABSTRACT.

This paper describes two small boats operated by producer gas—the *Mary A. Sharp,* 66 feet long by 14 feet 6 inches beam with 5 feet 3 inches depth of hold and a 75 brake-horsepower producer and engine outfit, and the *Superior,* 65 feet long by 12 feet 9 inches beam, 4 feet depth of hold, equipped with a 50 brake-horsepower producer and engine.

The same general description will cover the interesting points of the power equipment of both boats. The producers used in both installations are the same type and make as fitted in the *Marenging* and *Carnegie.* The producer as shown in the photograph is a cylindrical steel shell lined with asbestos and fire-brick to such a thickness that, when running at full load, the heat radiation is not important. While the shell is rather warm to the touch, it cannot be regarded as hot. With proper ventilation this heat in summer is not objectionable, while it is most agreeable in other seasons of the year. The whole principle being one of suction or vacuum, there is no escape of gas into the boat. The writer has been aboard the *Mary A. Sharp* after she had been closed up for a week, excepting about half an hour every other day, when a little additional draft was given to the producer to keep the fire alive, and found no odor of gas in the engine room. At a suitable distance above the bottom to form an ashpit is located the grate and on a line with this are two fire-doors for slicing the fire and raking off the ashes. An ashpit door is fitted for the removal of ashes and clinkers. The coal is fed into the producer through a hopper on top and just below, reaching into the center, is the gas take-off pipe. The side walls of fire-brick are substantially vertical and we have then a fire-brick lined cylinder filled with anthracite pea coal in various stages of combustion. While operating, the hottest fire zone is from six to eighteen inches above the grate. Above this is a red hot and black hot layer of coal extending up to the take-off pipe. The top of the producer is effectively insulated by a considerable layer of coal around and above the take-off pipe. Thus it will appear that the producer itself is extremely simple.

Contrary to general land practice there is no water vaporizer whose function is to generate steam vapor which, mixed with the air and passed through the fire, serves the double purpose of enriching the gas (the steam forming water gas) and softening the clinker. A number of attempts have been made to incorporate this device with marine producers but without success, owing to the deposit of salt and the effect on the vaporizer of the rolling and pitching of the vessel. It is in fact a mooted question whether the presence of considerable water gas is not a detriment rather than an assistance to a smooth-running engine. This being the case, it is only necessary to find a substitute for steam for the softening of the clinker. Exhaust gas introduced under the grate has this effect. The exhaust line from the engine is accordingly tapped and a portion of the exhaust by-tapped to the producer. To keep the ashes and the bottom of the producer cool a small quantity of water is run into the ashpit, say fifty drops per minute on a 75-horsepower producer. Such steam as is formed from this small amount of water, of course, is turned into water gas and assists slightly in keeping down the clinkers.

With proper care the grate should last two years or more as the best operating conditions require a layer of ashes between the grate and the hottest fire zone. The fire-brick lining is good for three to five years according to usage and the skill of the operator. Relining is comparatively inexpensive.

The gas is taken off near the top of the producer through a two-way water-cooled valve, one outlet to the scrubber and the other to the purge stack. The latter carries off the gases from the producer when the engine is not drawing same through the scrubber. The purge pipe should be of sufficient height to induce enough natural draft to keep the fire alive when standing by for long periods—weeks if desired. The purge pipe is most conveniently run into a dummy stack which may also contain the exhaust mufflers. The scrubber, whose function is to cool and clean the gas, is shown in the photograph of the *Mary A. Sharp* located on the top of the engine-room house and after the stack. It is of the static type, is cylindrical in shape, and fitted with baffles, each section being provided with three water sprays. The material is copper and monel metal, to withstand the effect of salt water from the sprays and sulphuric acid from the gas.

Perhaps the most interesting feature of these two installations is the engine. It is two-cycle in principle, in that an explosion is effected in each cylinder each revolution, scavenging in action and substantially equivalent to the four cycles in efficiency. The commercial use of producer gas on shipboard involves the vital questions of weight, space, first cost, and simplicity. The two-cycle principle naturally appeals to the imagination of the marine engineer as fulfilling these requirements more easily than the four-cycle provided it can be made economical and reliable. In land practice we know of the Koerting two-cycle engines which are economical on full loads. Now a marine engine is operated at full power continuously. Hence it is evidently possible to fulfil the specifications for economy. Reliability is a matter of careful design, good material and workmanship, and high-grade ignition devices. If the use of a four-cycle engine is made difficult by reason of its weight, space required and first cost, the two-cycle engine should make marine producer gas power installations commercial.

The engines, as stated, are two-cycle. The explosive charge after expansion is completely blown out by a charge of air before the gas is admitted to the cylinder. The admission of the latter is so timed that none of the gas is lost through the exhausts ports. This gives a clean charge of great power and efficiency, and without any possibility of back-firing. Producer gas is particularly susceptible to back-firing, due to its slow burning, and in eliminating all back-firing in the type of engine described a decided forward step has been made. The saving in heat losses and in friction due to an explosion every revolution in each cylinder compensates in large part for the loss in the air and gas compressors. The working cylinders are of the ordinary construction, but with exhaust ports extending around the entire circumference of the cylinder. The exhaust gases pass with the utmost freedom from the cylinders to a large water-jacketed exhaust manifold. Differential pistons and cylinders are used as gas pumps. The downward stroke of the piston induces direct suction on the producer compressing same into a receiver on the upward stroke. This receiver communicates with the cylinder heads and the air and gas valves controlling their admission. Air only is drawn into and compressed in the base and of a volume of about 50 percent in excess of both the working piston displacement and the clearance in the combustion chamber. Both air and gas are admitted to the cylinder through mechanically operated valves and are so timed that such a proportion of the air as is intended for scavenging is firstly admitted, blowing out the burnt gasses. The gas valve is then opened, admitting gas direct to the cylinder and mixing with the balance of the air from the base.

The trials of the *Mary Sharp* were quite exhaustive and some interesting data was secured. On a non-stop run of eighteen hours' duration the engine averaged 60.8 indicated horsepower at 234.5 revolutions per minute; the coal burned per indicated horsepower per hour was 1.13 pounds; the weight of the engine and producer per brake-horsepower at the commercial rating of 75 brake-horsepower is 205 pounds.

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The Armaments of Battleships.

The various elements of battlehip design are so closely related that any discussion of a single element must necessarily be modified by a consideration of all the other elements. In considering the armament of a battleship it must be borne in mind that every fraction of the displacement of the ship which is devoted to armament must be at the expense of some other quality of the vessel, either of the armor protection, the speed or the steaming radius. Furthermore, when the most desirable relation is established between those elements, we find that, when it comes to the placing of the armament on the vessel, obstacles are met in the internal arrangement where as much attention must be given to the placing of the machinery as to the placing of the magazines, handling rooms, etc. Such considerations as these make it impossible to consider the question of armament irrespective of the other qualities of the ship.

The modern tendencies in the armament of battleships are fully outlined by Sir William White in a paper of exceptional value read at the annual meeting of the Society of Naval Architects and Marine Engineers. The author's arguments are mainly a protest against the present tendency to increase the size of armaments on battleships. His position regarding the matter is summed up in the statement that in no case is it desirable to carry more than the eight heavy guns in a single ship; that these guns are best arranged in four positions, as in the *Michigan* class, and that they should be supplemented by a powerful and well-protected secondary armament. In addition to this, the author expresses the belief that the present tendency toward the use of larger caliber guns than the 12-inch is but temporary, and that in the course of time the fashion in warship design will again revert to the use of the 12-inch gun.

There is no doubt but what the armament suggested by Sir William White is one in which the maximum efficiency can be gained for each element of the armament. Limiting the number of big guns to eight permits the guns to be mounted in what is generally accepted to be the most efficient manner possible—namely, that which was first used on the United States battleships *Michigan* and *South Carolina*—while this disposition of the main battery also leaves room for the most effective emplacement of the secondary battery. Apparently there is strong belief that at present such an armament, involving the use of 12-inch and 6-inch guns, is sufficiently heavy for all practical purposes. Twelve-inch shells will pierce any armor which is now used on a battleship, so that the only effect gained by increasing the caliber of the guns is to increase the bursting power of the shell; and just how useful this would be, in view of the fact that, by using lighter guns, probably a more rapid rate of fire would be maintained, is debatable. Although it is generally conceded that future naval battles will be fought at long range, it is, nevertheless, true that atmospheric conditions will at times very materially reduce the range, and, consequently, make the lighter secondary armament doubly effective. It is unfortunate that, after such a frank and complete expression of opinion regarding the subject has been made by the leading authority in Great Britain, naval officers in America are not permitted, on account of official regulations, to be equally frank in their discussion of the paper, since the tendency toward larger ships and heavier armaments is nowhere more apparent than in the United States navy.

In the discussion of the paper, however, one subject was touched upon which, it seems to us, should not be overlooked in the consideration of armaments, and that is the importance of under-water attack, either by torpedoes, submarines or mines. Submarine warfare is bound to play an important part in any future engagements, and the possibilities of striking an effective blow at the enemy in this manner are daily becoming greater as further progress is made in the development of the range and accuracy of torpedoes and in the increase in size and efficiency of submarines. Although litle consideration seems to have been given in existing war vessels to protection against such at-

tack other than the use of a deep and minutely subdivided double bottom, yet it seems almost imperative that future vessels should have some more adequate form of protection against such attack.

Protection from Fire on Board Ship.

The risk of fire at sea can never be eliminated so long as ships are built of inflammable materials, and since at present it is impossible to build ships which are absolutely fireproof, this risk must be given careful consideration. Even in steel cargo vessels, where the construction is as nearly fireproof as possible, there is still the risk of fire in the cargo. Needless to say, almost every fire on board ship occurs through carelessness. Spontaneous combustion sometimes occurs with some forms of cargo or with coal, but it is not so difficult to fight a fire which is confined to a coal bunker or to a special cargo hold, where the progress of the fire is apt to be slow, as it is to overcome one which sweeps through the passenger accommodations on a vessel or through a deck load of miscellaneous cargo.

The number of ways in which fires originate on board ship are clearly pointed out in one of the papers read at the annual meeting of the Society of Naval Architects, and some valuable suggestions are given as to the best methods of preventing them. One point was brought out in the discussion of the paper by a representative of the New York City fire department which deserves consideration, and that is that, as a rule, steam is not effective for putting out cargo fires on board ship; its use frequently results in greater damage than the fire itself, due to the excessive heat maintained in the hold for a long period of time. It was suggested that a better means of fighting such a fire is to have a piping system installed whereby water can be poured into the holds instead of steam. This, as was pointed out by one of the members, theoretically should be more effective than the use of steam, since the introduction of water, while it does not smother the combustion, as does steam, by driving out the air, nevertheless takes away the heat at a rapid rate, and, at the same time, gradually saturates the cargo until the fire is put out.

A great deal of thought and attention is given to the question of fire protection in the design of every modern steamship, and the comparative freedom from disastrous fires on passenger vessels and the small loss of life from this cause are sufficient testimony to the good results which are obtained. It must not be forgotten, however, that on board ship there is not only a large crew continually on watch, so that a fire has little chance to gain headway before being discovered, but also the passengers themselves occupy such a large share of the boat that few parts of the vessel, except the cargo holds, are not constantly in view of someone. This in itself is one of the greatest means of protection against the spreading of fire on board ship. The more or less frequent occurrence of fires on board vessels while laid up in port and the comparative infrequency of disastrous fires while the ships are in commission bear out this statement, and should give the traveling public a sense of security from danger from this source which they might not have from a realization of the fact that vessels are built largely of inflammable materials.

The Gyroscope.

Of all the purposes for which a gyroscope can be used on board ship, the one which has engaged most attention is that for the prevention of the rolling of ships. Various other devices have been suggested and even developed with a great deal of care and thought to accomplish this same purpose, but apparently the gyroscope in its present stage of development offers more advantages for this work than any other device which has yet been proposed. The importance of reducing the rolling of ships may have been overlooked by many because the problem has seemed so difficult to solve, yet when it is considered that, in reducing or preventing the rolling of ships, we immediately add greatly to the safety and comfort of passengers at sea, as well as prevent the deterioration of certain classes of freight, such as live stock, besides providing better conditions for gunnery on war vessels, it is at once evident that the problem is worthy of a great deal of attention. According to the views expressed at the annual meeting of the Society of Naval Architects, where the subject was fully discussed, a modern gyro-steadying plant of the active type is now well within the practical limits of space, weight and cost suitable for application to steamships. It was stated that the weight of such a device for each degree of roll-quenching power on a modern battleship would be about one-tenth that of the submerged armor displaced and cost much less. With this type of gyroscope it has been found that a small part of 1 percent of the displacement of the ship will perform a very substantial service down to the point of practically fully extinguishing the rolling. The immense power of the gyroscope can readily be seen when it is understood that every pound in the rotating mass of the gyroscope can easily be made to do the work of from 150 to 200 pounds, and, furthermore, this force can be directed in any desired line or plane. Where this result can be obtained on such a slight increase in displacement and where the apparatus takes up only a moderate amount of space and the investment required is not excessive, it is evident that the gyroscope, as a means for preventing the rolling of ships, is bound to play an important part in future in the design of certain classes of vessels. The adoption of bilge keels for decreasing rolling has now become almost universal, and yet their effect is slight as compared to the effect of a gyroscope, particularly at small angles of heel.

Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, reports the following percentages of completion of vessels for the United States navy:

BATTLESHIPS.

	Tons.	Knots.		Oct. 1.	Nov. 1.
Florida	20,000	20¾	Navy Yard, New York	77.4	80.6
Utah	20,000	20¾	New York Shipbuilding Co.	88.0	89.9
Arkansas	26,000	20½	New York Shipbuilding Co.	47.8	50.1
Wyoming	26,000	20½	Wm. Cramp & Sons	38.9	43.3

TORPEDO-BOAT DESTROYERS.

Drayton	742	29½	Bath Iron Works	94.4	100.0
Terry	742	29½	Newp't News Shipbuilding Co.	99.0	100.0
Perkins	742	29½	Fore River Shipbuilding Co.	97.4	98.1
Sterrett	742	29½	Fore River Shipbuilding Co.	90.8	92.5
McCall	742	29½	New York Shipbuilding Co.	95.9	96.0
Burrows	742	29½	New York Shipbuilding Co.	94.9	95.1
Warrington	742	29½	Wm. Cramp & Sons	84.7	89.1
Mayrant	742	29½	Wm. Cramp & Sons	83.7	86.7
Monaghan	742	29½	Newp't News Shipbuilding Co.	35.6	46.1
Trippe	742	29½	Bath Iron Works	68.3	76.0
Walke	742	29½	Fore River Shipbuilding Co.	57.5	66.5
Ammen	742	29½	New York Shipbuilding Co.	72.4	76.5
Patterson	742	29½	Wm. Cramp & Sons	47.8	51.7

SUBMARINE TORPEDO BOATS.

Seal	...	..	Newp't News Shipbuilding Co.	55.9	71.4
Carp	...	..	Union Iron Works	63.0	70.0
Barracuda	...	..	Union Iron Works	64.8	71.1
Pickerel	...	..	The Moran Co	61.1	64.3
Skate	...	..	The Moran Co	61.1	64.3
Skipjack	...	..	Fore River Shipbuilding Co.	56.3	57.5
Sturgeon	...	..	Fore River Shipbuilding Co.	55.4	57.8
Tuna	...	..	Newp't News Shipbuilding Co.	32.4	33.9
Thrasher	...	..	Wm. Cramp & Sons	15.7	20.2

ENGINEERING SPECIALTIES.

Austin Rotary Engine.

A triple-expansion reversible rotary engine is being placed on the market by the Austin Rotary Engine Company, Second avenue and Eighth street, Brooklyn, N. Y. Each expansion stage of the engine is constructed with a middle section, and a half section on each side of it, the size of the middle section being just twice that of the outer sections, and, as the middle and outer sections are diametrically opposite, the forces are balanced. Steam is controlled by a piston valve on top of the engine, and a simple movement of this valve throws the engine from ahead to reverse, or in the mid position steam is shut off entirely. In a compound or triple-expansion engine of this type the valves on the several stages of the engine may be controlled from a single lever. In a triple-expansion engine the intermediate stage is four times as large as the high-pressure, and the low-pressure is six times as large as the intermediate; therefore, giving a theoretical expansion to twenty-four volumes and an actual expansion of about twenty. The best results are obtained through the use of a condenser and a 26-inch vacuum.

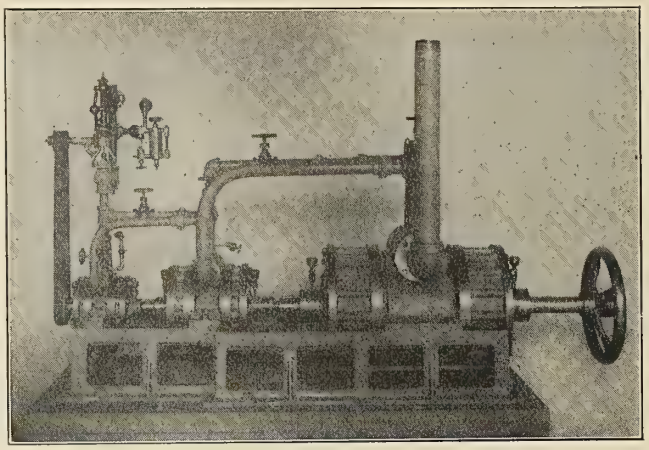


FIG. 1.

The construction of the pistons is shown in the line cut. There are four pistons in each section which are connected through the hub and shaft by means of rods. These bars are inserted in sockets in the inner sides of the opposing pistons and on each end of each piston is an oscillating face plate, connected to the piston by a ball joint. A tight joint is maintained between the cylinder walls and the face plate by the admission of steam through suitable passages behind the piston forcing it out against the cylinder wall on the working stroke. In Fig. 2 the spaces *O* and *P* are filled with steam.

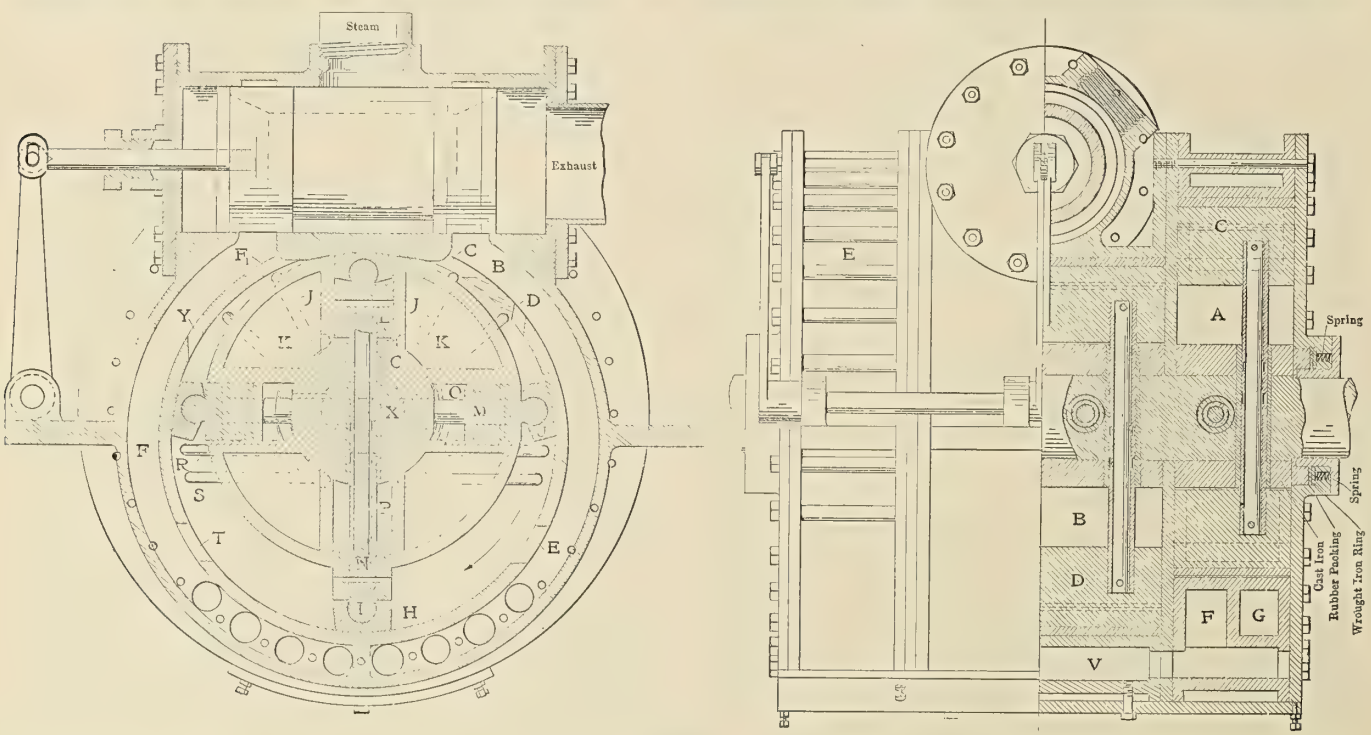


FIG. 2.

On the latter part of the stroke this steam is exhausted. By this method it is claimed that the pistons can be readjusted as wear occurs.

When the engine is turning in the direction shown in Fig. 2, steam enters the space *B*, and, passing into the grooves *J* and *K*, forces the piston *M* out from the center of the hub *X*. At the same time steam is entering the port *D*, but exerts practically no power on the piston *M*, as the pressure on both sides is about equal, but the steam entering the port *E* is practically opposed by the entire area of the piston *M*, and the pressure causes this piston to move in the direction of the arrow. When the piston *L* reaches the port *C*, *M* passes the port *E*, the steam entering through the port *D* acts upon the piston *M*, and when it has passed the port *E* the piston *L* reaches the port *D*, and the rotation of the hub *X* is produced by the pressure of the steam on the piston *M*. During this period the piston *M* is moved by the exhaust side of the cylinder, and when it passes the exhaust port *F* the steam escapes to the passages *F* and to the exhaust port. If the engine is reversed, the action of the steam is the same only in a reverse direction.

The shaft is packed by a special form of packing, which consists of a spiral spring against which a wrought iron ring rests and next a soft rubber packing, on top of which is placed a cast iron ring, the whole being placed in annular grooves which are provided in each hub concentric to the shaft. The soft packing expands against the side of the annular groove, packing the groove and so preventing the leakage of steam. It is claimed that leakage of steam by the piston is not excessive and that the steam consumption of the engine is about the same as that of a well-designed reciprocating engine of similar power.

A 45-horsepower engine operating at 400 revolutions per minute has been in successful operation in a 50-foot launch for several months, where its freedom from vibration, its durability and excellent maneuvering powers have been repeatedly demonstrated.

A New Type of Gas Engine.

A gas engine which combines the two and four-cycle principles in a single motor is being placed on the market by the New York Engine Company, 165 Broadway, New York. This engine is the invention of John L. Bogert, consulting engineer of the above company, who has had a small engine of this type in operation for some time at the Fulton Foundry & Machine Company, Brooklyn, N. Y., where the features of the engine were demonstrated.

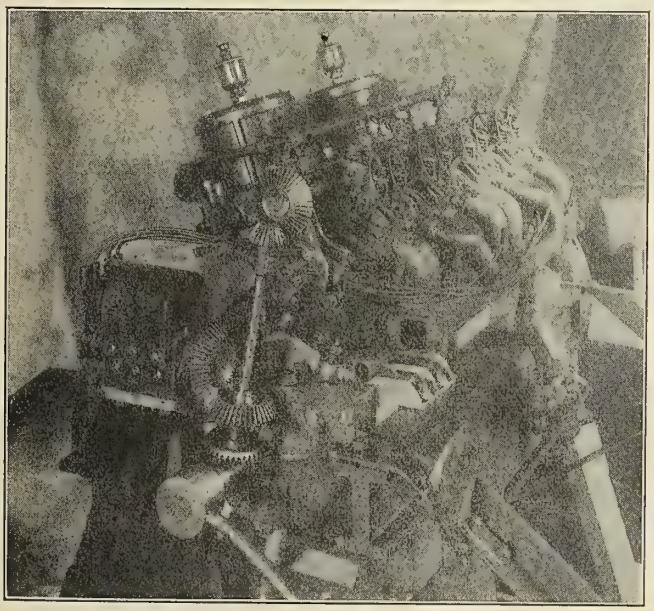


FIG. 1.—VIEW OF FOUR-CYCLE CYLINDERS.

The combination of the two and four-cycle cylinders and the manner in which they operate can be seen from the sectional drawing and the photographs. In the experimental engine there were six 4-cycle cylinders, 4 inches by 3 inches,

FIG. 2.—VIEW OF TWO-CYCLE CYLINDERS.

and two 2-cycle cylinders, 5 inches by 3 inches. The fuel used was gasoline (petrol) supplied in the ordinary manner to the 4-cycle cylinders. The customary intake and exhaust ports are arranged in these cylinders and controlled by a cam shaft driven from the main shaft by bevel gears. The combustion space of the 4-cycle cylinders is connected to the space underneath the pistons of the 2-cycle cylinders by passages which are closed by poppet valves. These valves are kept closed by the pressure of the air, which is compressed in the 2-cycle cylinders and remain closed until the charge is ignited in the

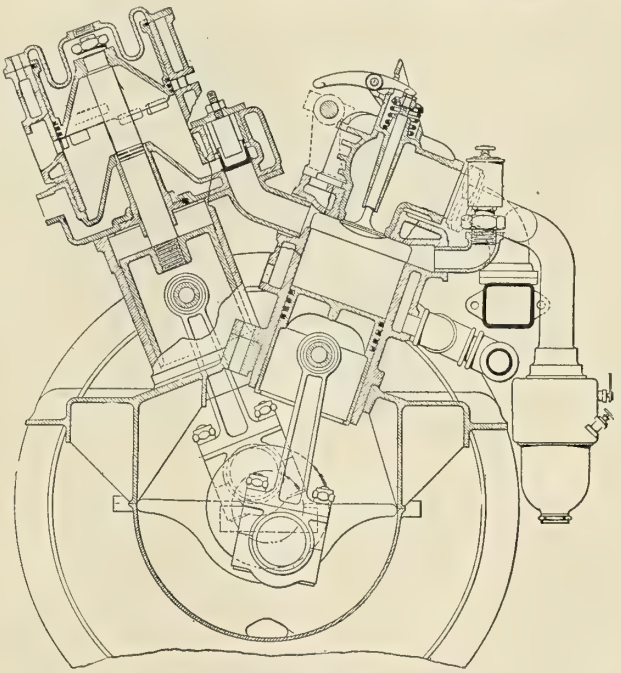


FIG. 3.—SECTIONAL VIEW OF ENGINE.

4-cycle cylinders, when the pressure immediately rises and overbalances the pressure of the compressed air on the 2-cycle side, raising the valves and admitting a portion of the burning gases to the space below the 2-cycle pistons. This part of the charge, mingling with the compressed air, carries out the working stroke in the 2-cycle cylinder and, on account of the excess air, it is claimed that the combustion is complete.

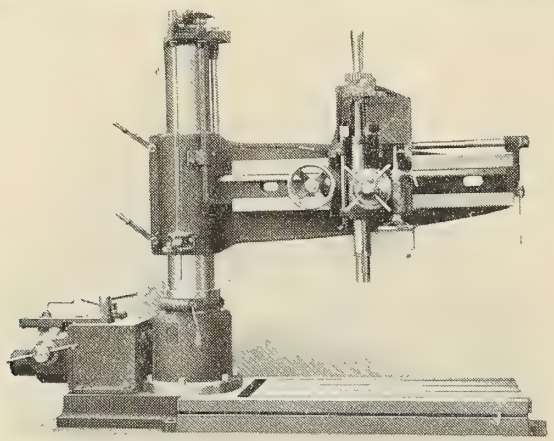
Each 2-cycle cylinder is connected to two of the 4-cycle cylinders, and the space above the 2-cycle pistons is used for compressing air on the upward stroke of the piston. This compressed air is transferred from the upper to the lower side of the piston when the piston reaches the top of its stroke by means of ports in the cylinder wall. When the 2-cycle piston is at the end of its downward stroke it uncovers a port in the wall and admits a fresh charge of air above the piston.

The temperature of the exhaust gases from this engine is very much lower than the temperature of the exhaust from an ordinary 4-cycle gas engine, and this, together with the greater expansion and complete combustion of the fuel, it is claimed, results in greater fuel economy than can be obtained with engines operating on the ordinary cycle. The action of the engine is somewhat like that of a Diesel engine, except that the high pressures and high temperatures and the consequent difficulties attending the upkeep of the engine under these conditions are eliminated. The engine can be operated on either gasoline (petrol), heavy oils or producer gas, and it is particularly adapted for marine work.

High-Speed Radial Drill.

George Swift & Sons, Halifax, have on the market a type of high-speed radial drilling, tapping and studding machine with gear box drive and geared feeds which has been designed to meet the demand for a rigid machine to stand up under the severest duty, and to deal with high-speed drills at their greatest speeds and feeds and be easy in manipulation in all movements.

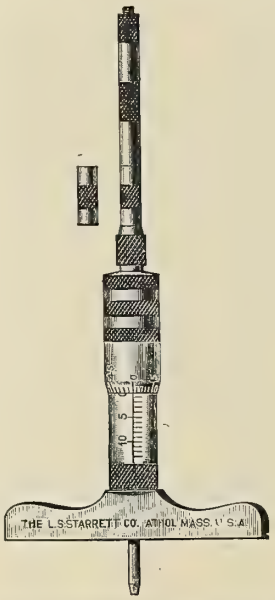
The arm is raised and lowered by power through gearing on top of the column. The saddle is moved along the arm by means of a rack and pinion. The spindle is fitted with ball



thrust washers at both ends, and provided with hand and power feeds, a quick advance and return and a reverse motion for tapping. The spindle is balanced by a spring instead of a counterweight. The reversing motion is carried at the back of the saddle by a double clutch, controlled by a lever in front of the saddle, giving complete control for the spindle without interfering with any other part of the machine. There are sixteen changes of speed which are controlled by three levers. No friction clutches are used, and all of the speeds are positive. This machine can be driven direct from the main line shaft, dispensing with countershafting, and is furnished in sizes from 4 feet 6 inches, which has five changes of feed, to 6 feet and 7 feet 6-inch machines, which have nine changes of feed.

Starrett Micrometer Depth Gage.

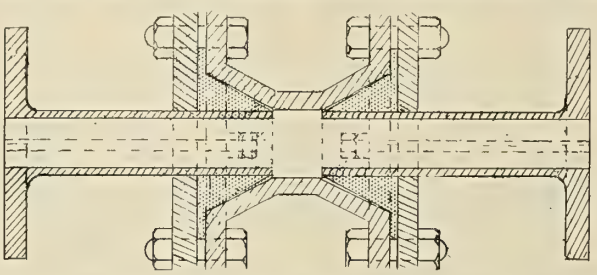
This gage is designed for measuring the depth of grooves, holes or irregular parts. It has a ½-inch movement of the screw reading in thousandths, and with two ½-inch and one 1-inch standard collars to slip off or on the spindle 2½-inch readings in thousandths can be obtained. The split nut is covered and protected by a patent graduated sleeve, which not only protects the nut from dirt but provides a quick and



accurate way of taking up wear and adjusting the micrometer to insure correct reading. The sleeve being held by a stiff friction may be rotated by a spanner, so that the zero lines will coincide for correct reading. The head is about 3/10 inch thick. This and the point of the measuring rod are hardened. This tool is manufactured by the L. S. Starrett Company, Athol, Mass.

The Goodby Expansion Joint.

The illustration shows a sectional view of an expansion joint manufactured by Goodby's Limited, 24 Great Tower street, London, E. C. This joint acts as a union and is suit-



able for all pressures of superheated and ordinary steam as well as for hot-water piping. There are no packed glands, and it is claimed to be very sensitive, due to the small area of rubbing surface. This also makes it adapted to light steel piping. The conical rings of the Goodby joint are claimed to give exceptional strength and durability.

Flexible Covering for Ferry Racks.

Ferry racks are peculiar structures which differ from all others. The converging walls of the rack are necessarily made of wooden piles, connected together by cords, to produce a structure strong and firm enough to resist the impact of the boats, and, at the same time, having a resilient character, so as to yield sufficiently to such impact. It has been shown on various ferry properties that the timber of this nature, when it has been protected by a covering from the rain, sun and

snow, has universally given an increase in life of double that unprotected and exposed to the weather; and to provide such protection a unique form of a flexible covering for ferry racks has been designed and patented by F. W. Bacon, Englewood, N. J.

This sectional covering is peculiarly arranged and supported, so that it will not interfere with the varying and irregular movement of the rack, nor will it be displaced, crushed or damaged due to the extreme flexible nature of its design. It consists of a series of frames, 12 feet in width, covered with a suitable water shedding material. The frames are supported by flexible hangers, fastened by means of an eye-bolt to a cord run on the beveled top of the front row of piles. The frames adjacent to their upper edges rest upon this cord to which they

are thus connected. A similar cord is run on the back of the lowest row of piles to be covered, upon which the lower end of the frames rest. There is thus produced a sectional protection curtain, so supported that it is free to move in full relation to the piles. The length of the cover varies according to the individual rack, number of rows of piles, etc. It is entirely applicable to any form or design where rigid construction is not practicable. The top of the rack is protected by a sectional covering held in position by a cleat against the facing planks. The entire covering can be removed or replaced on the rack in a very short time when found necessary during a period of repairs.

Ferry racks represent a large investment, with a high maintenance cost that is increasing annually in proportion to the increased cost of labor and materials, and experience with this flexible covering at the West 130th street rack of the Riverside and Fort Lee Ferry Company, New York, has shown that by its use the maintenance cost can be greatly minimized.

Obituary.

Louis C. Taylor, secretary of the Durable Wire Rope Company, Boston, Mass., died Thursday, October 27, 1910.

Correction.

In the article "Some Data on Paddle-Wheel Steamers" on page 445 of our November issue, mention is made of the steamers *Middlesex* and *Maryland* in a manner that is somewhat misleading, giving the impression that these boats are of the Mississippi River type since they are called "Southern River and Harbor Steamers." As a matter of fact, these vessels ply on the comparatively deep and often rough waters of the Chesapeake Bay and its numerous tributaries. The *Middlesex* is owned by the Maryland, Delaware & Virginia Railroad Company, and the *Maryland* by the Baltimore, Chesapeake & Atlantic Railway Company, two affiliated companies owning and operating about forty steamers.

TECHNICAL PUBLICATIONS.

Heat Engines. By John R. Allen and Joseph A. Bursley. Size, 6 by 9 inches. Pages, 288. Illustrations, 157. New York, 1910: McGraw-Hill Book Company. Price, $3 net.

As this book is intended as an elementary text-book, the subjects, which include steam and gas engines, steam turbines and their auxiliaries, are all treated in as simple and elementary a manner as possible. The higher mathematics are avoided almost entirely except in a single chapter on elementary thermodynamics. Compared with many text-books on heat engines, perhaps this one will seem unduly brief, but it should be remembered that it is intended to be used in connection with class work for the instruction of students in these subjects, and that all the matter included in the book is simply the basis of the work which is to be amplified in the class room. A great deal of material, however, has been condensed into a small space, and by the use of timely illustrations the text is made exceedingly clear and useful. In each division of the text, problems have been worked out in detail to show the application of the subject matter which is treated, and a large number of problems have been introduced for class-room work. The design of engines has not been considered, as it was felt that that subject did not properly come within the scope of this work.

Engineering Reminiscences. By Charles T. Porter. Size, 6 by 9 inches. Numerous illustrations. New York, 1908: John Wiley & Sons. Price, $3 net.

Owing to the recent death of the author of this book the attention of many engineers, particularly of the older men of the present generation, will be turned toward this record of Mr. Porter's engineering work. The book is essentially an autobiography, in so far as it concerns the professional side of the author's life. It is written in a particularly pleasing style, and touches on many important events in the engineering world during the last half century.

Mr. Porter was born in Auburn, N. Y., and graduated at Hamilton College, and was soon after admitted to the bar. He practiced law in Rochester, N. Y., and New York City for six or seven years, but soon had his attention turned to mechanics by some of his clients who were bringing forward various mechanical inventions. His first successful venture in the mechanical field was the design of a stone-dressing machine, which had been brought to his attention by a client. This machine was run at very high speed, and laid the foundation of Mr. Porter's ideas which subsequently were developed in the high-speed engine for which he is famed. Mr. Porter's next invention was a weighted governor, which proved a great success. This governor was used in a great many installations, but Mr. Porter had considerable difficulty in introducing it in the marine field. He designed a special marine type of governor which was first installed on the first North German Lloyd liner *New York*. Its successful operation on this vessel led to its general use on simple marine engines.

Soon after the development of the governor, Mr. Porter became acquainted with Mr. J. F. Allen, who had in mind a new type of valve gear operating a double-ported valve giving large opening and small lap. Mr. Porter was very much impressed with this design, and, together with Mr. Allen, worked out the design of a high-speed engine. In connection with this engine, Mr. C. B. Richards invented his well-known indicator, for which Mr. Porter purchased the patents. Space does not permit of going into the history of the development of the high-speed engine, nor, in fact, is it necessary, as it is well known to most engineers.

During the last few years of his life Mr. Porter was engaged in consulting engineering work, and in 1909 he was awarded the John Fritz medal by the American Society of Mechanical Engineers, of which he was an honorary member.

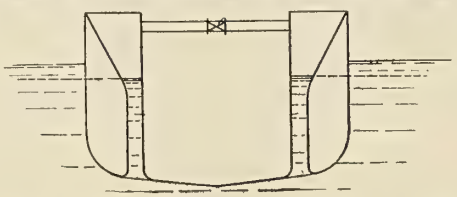
SELECTED MARINE PATENTS.

The publication in this column of a patent specification does not necessarily imply editorial commendation.

American patents compiled by Delbert H. Decker, Esq., registered patent attorney, Loan & Trust Building, Washington, D. C.

968,927. MEANS FOR PREVENTING THE ROLLING OF SHIPS. HERMANN FRAHM, OF HAMBURG, GERMANY.

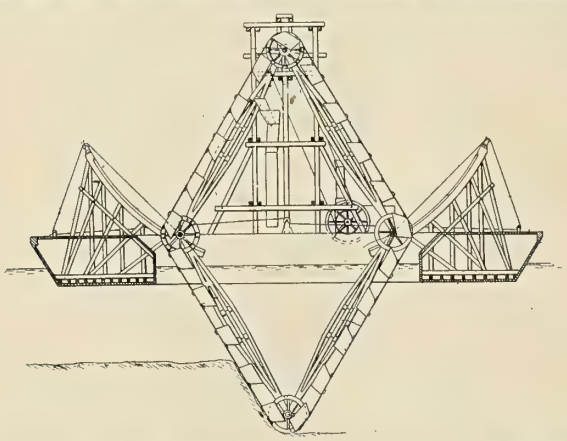
Claim 1.—Apparatus for damping the rolling motion of ships having within the ship, a vertical chamber at each side of the ship, said



chambers being widened upwardly and connections from the bottom end of each of said chambers to the sea water, said chambers and connections being so diminished that the periodic oscillations of water in and out of said vertical chambers are substantially equal to the natural period of oscillations of the ship. Four claims.

969,171. UNIVERSAL DREDGING MACHINE. THOMAS F. LONNEY, OF BROOKLYN, N. Y., ASSIGNOR TO GEORGE UPINGTON, OF BROOKLYN, N. Y.

Claim 2.—A float, a derrick carried thereby, a pair of trusses pivoted to said derrick, each being adapted to be moved with or independently of



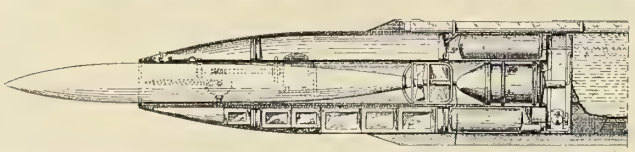
its companion, trusses hinged to the lower portions of said swinging trusses and converging to form a toe, and an endless chain of buckets mounted to travel around the aforesaid frame work, whereby upon swinging one or both of said swinging trusses the toe of said frame work may be raised or lowered to excavate at different depths. Thirty-five claims.

969,628. FASTENING FOR LIFE-BOAT COVERS. CHARLES F. HUDGINS, OF NORFOLK, VA., ASSIGNOR OF ONE-HALF TO FRANK M. PHILLIPS, OF WASHINGTON, D. C.

Claim.—The combination with a life boat and a removable canvas cover therefor, of a plurality of securing devices depending from the side of said cover, each securing device embodying a base plate having an eye at its upper end, a tongue pivoted at the lower end thereof, a loop pivoted to the plate intermediate said eye and tongue and adapted when swung down over the tongue to hold the tongue in locked position, and a lanyard connected with the loops, whereby the loops may be simultaneously raised and the tongue permitted to fall by gravity. One claim.

970,210. SUBMARINE TORPEDO BOAT. ALVARADO M. FULLER, OF TOPEKA, KANSAS.

Claim 1.—The combination with a buoyant tube or shell, of a torpedo

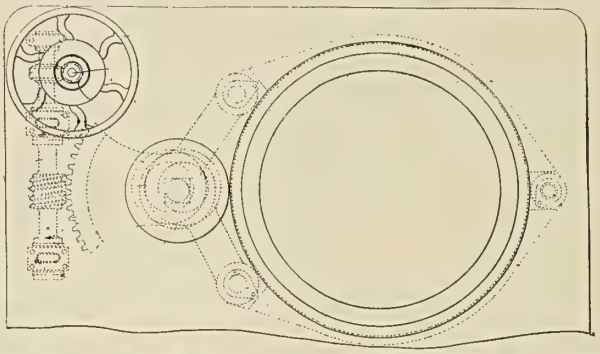


carried thereby and forming a bow therefor, and means thrown into action on the expulsion of the torpedo to form a temporary bow for the said tube or shell. Sixty-four claims.

British patents compiled by G. E. Redfern & Company, chartered patent agents and engineers, 15 South street, Finsbury, E. C., and 21 Southampton building, W. C., London.

6,349. BRAKE MECHANISM FOR CAPSTANS, WINDLASSES, ETC. CLARKE, CHAPMAN & CO., LTD., AND W. D. COOKSON, GATESHEAD-ON-TYNE.

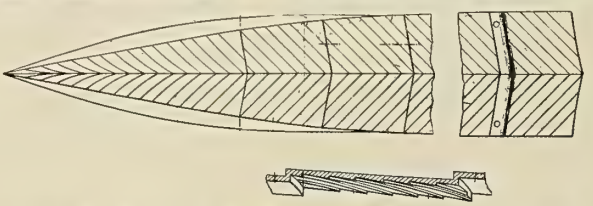
By this invention the straps of the eccentrics that move the ends of the brake band relatively to each other are connected to the ends of the band by links. The eccentric, on which the strap of one link is mounted, is displaced, in relation to the eccentric on which the strap of the other link is mounted so that both parts of the brake band are



simultaneously applied or released by a partial rotation. In another arangement the eccentric straps embrace a common eccentric. The lever carries a trunnion nut through which works a screw mounted in bearings and actuated by bevel gear from a hand wheel.

14,627. CONSTRUCTION OF BOATS AND SHIPS. W. H. FAUBER, NANTERRE, FRANCE.

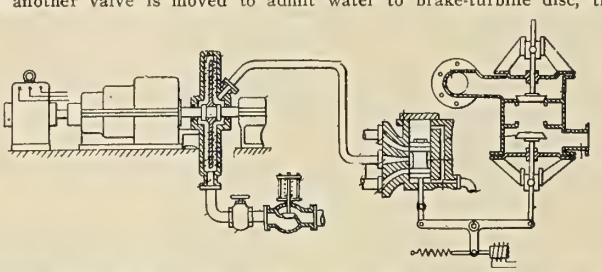
Relates to improvements in boats such as described in the inventors' specification No. 20,281—1908. According to the present invention, the auxiliary steps are arranged to run from the keel-line diagonally across



the hydroplane members; they commence at the side of the vessel and cross the bottom surface diagonally and rearwardly towards the keel. When these boats run at a high speed, only the rear portion of the hydroplane surfaces proper are in contact with the water, so that at each step between two hydroplane members an air-pocket is formed. Owing to the diagonal arrangement of the auxiliary steps, the air contained in this pocket passes along the diagonal channels and is spread in a thin film over the surface of the hydroplane member.

20,586. SYSTEMS OF PROPULSION. J. N. BAILEY, STRETFORD, LANCS.

Relates to means for braking the turbine rotor. In one form, an oscillating lever, by means of solenoid, steam is shut off by one valve and another valve is moved to admit water to brake-turbine disc, the

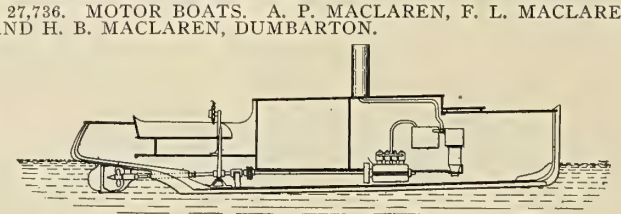


rotation of which is thus slowed down with the shaft of the main turbine, to which it is keyed. When not in use for braking, the disc rotates in vacuo and offers no resistance. Other forms of brake are described.

23,790 AND 28,976. STEERING VESSELS. M. G. HARRISON, NORTON-ON-TEES, DURHAM.

This invention relates to an indicator fixed to the stanchion for the ship's awning in the center of the fore part of the bridge deck rail, and comprises a vertical arm pivoted in a frame. This frame is secured to the stanchion and carries at its extremities adjustable pulleys geared by cords to pulleys at the lower end of the arm. These cords are carried suitably to a drum on the steering wheel spindle, so that one cord or the other is pulled by the rotation of the wheel to move the arm from its mid position towards starboard or port.

27,736. MOTOR BOATS. A. P. MACLAREN, F. L. MACLAREN AND H. B. MACLAREN, DUMBARTON.



The invention comprises a novel combination of a producer, internal combustion engine and reversing or folding propellers.

29,321. LOADING SHIPS BY CABLE-WAY CONVEYOR. H. O. ADAM, DRESDEN, GERMANY.

Relates chiefly to devices for preventing winding of the slings upon the transporting cable. The slings are placed on sleeves (open at bottom so that slings may pass under them) loaded and pushed off on to the cable. Each pulley has a guiding horn, which compels the sling to pass on the free side of the pulley so that it cannot twine about the cable; or the pulley may be arranged angularly. The loads are discharged by destroying the slings.